US006470872B1

(12) **United States Patent**
Tiberius et al.

(10) **Patent No.: US 6,470,872 B1**
(45) **Date of Patent: Oct. 29, 2002**

(54) **SEMI-AUTOMATIC FIRING COMPRESSED-GAS GUN**

(76) Inventors: **Benjamin T. Tiberius**, 564 Hillside Cir., Alpine, UT (US) 84004; **Dennis E. Tiberius**, 564 Hillside Cir., Alpine, UT (US) 84004; **Kyle L. Hansen**, 1239 W. 1480 North, Orem, UT (US) 84057

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/541,786**

(22) Filed: **Apr. 3, 2000**

(51) **Int. Cl.**[7] **F41B 11/06**
(52) **U.S. Cl.** **124/74**; 124/56
(58) **Field of Search** 124/56, 74

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,357,951 A	*	9/1944	Hale	
2,526,018 A	*	10/1950	Foster et al.	
3,572,310 A	*	3/1971	Chiba	
4,004,566 A		1/1977	Fischer	124/59
4,137,893 A	*	2/1979	Beauchamp	
5,280,778 A		1/1994	Kotsiopoulos	124/73
5,450,683 A	*	9/1995	Miller	
5,477,843 A	*	12/1995	Kunimoto	
5,505,188 A	*	4/1996	Williams	
5,542,406 A		8/1996	Oneto	124/73
5,664,552 A	*	9/1997	Kunimoto	
5,669,369 A		9/1997	Scott	124/73
5,704,342 A		1/1998	Gibson et al.	124/73
5,711,286 A	*	1/1998	Petrosyan et al.	
5,771,875 A	*	6/1998	Sullivan	
5,839,422 A	*	11/1998	Ferris	
6,073,620 A	*	6/2000	Kunimoto	
6,112,734 A	*	9/2000	Kunimoto	
6,158,424 A	*	12/2000	Kunimoto	

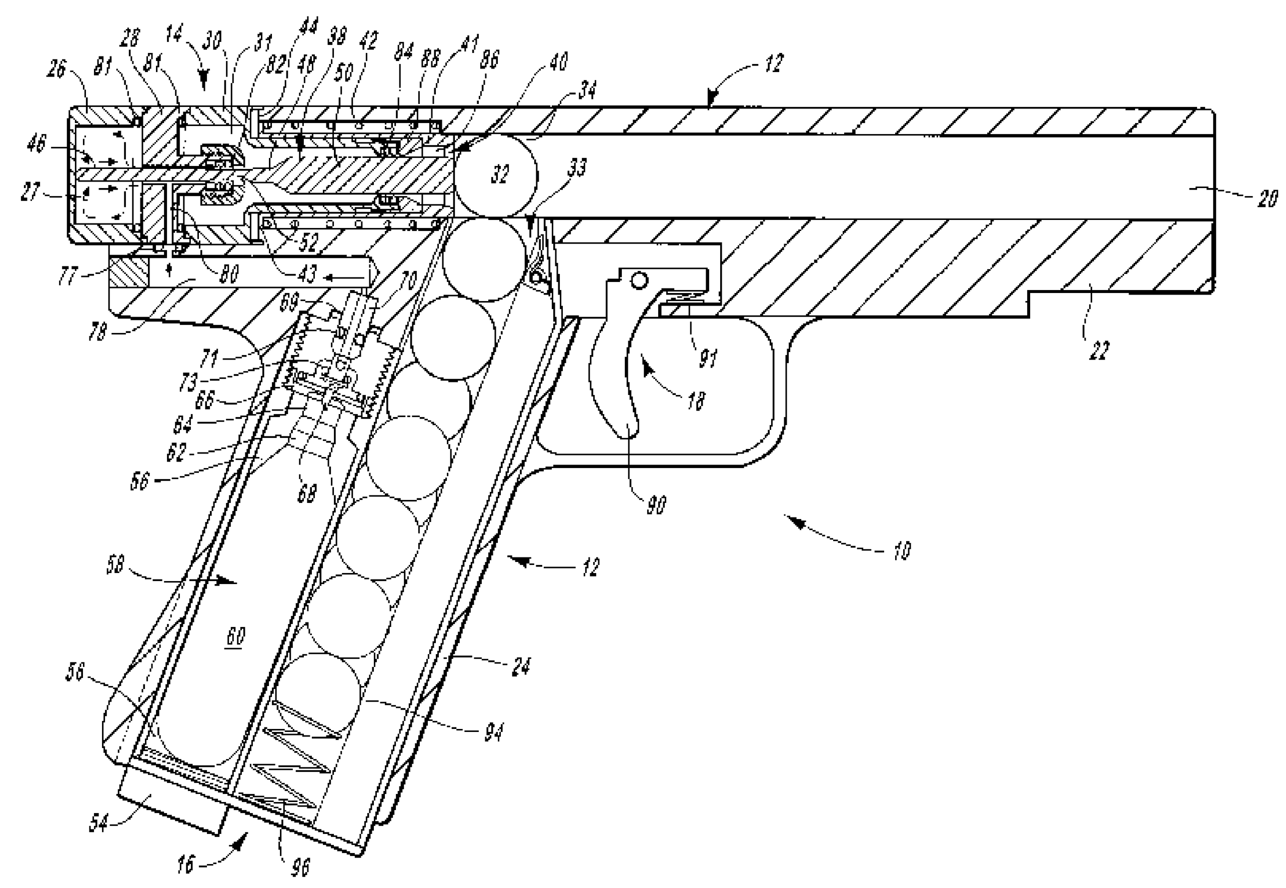
* cited by examiner

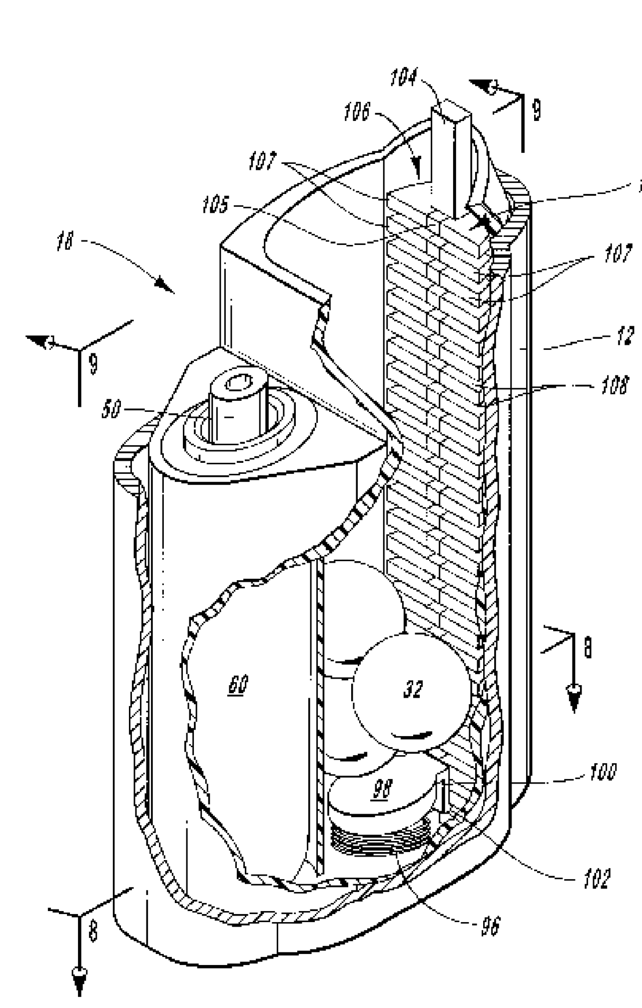
Primary Examiner—Charles T. Jordan
Assistant Examiner—Troy Chambers
(74) *Attorney, Agent, or Firm*—Pate Pierce & Baird

(57) **ABSTRACT**

A paintball gun is sized and designed to appear like and operate in a manner similar to a conventional gun. A dual-action firing bolt moves forward, assisting in launching a projectile, under cast pressure. The bolt then releases the compressed gas to carry the projectile down the barrel. Return springs operate to move the bolt and its valves to a ready-to-fire position. Similarly, trigger actuation mechanisms are spring-actuated to return to the ready-to-fire position. A removable magazine stores projectiles and propellant. The magazine is small enough to fit into a handle of a pistol. A user may selectively release just the projectile portion of the magazine, in order to leave the propellant undisturbed until fully expended. The magazine can be completely removed without substantial loss of propellant.

17 Claims, 19 Drawing Sheets





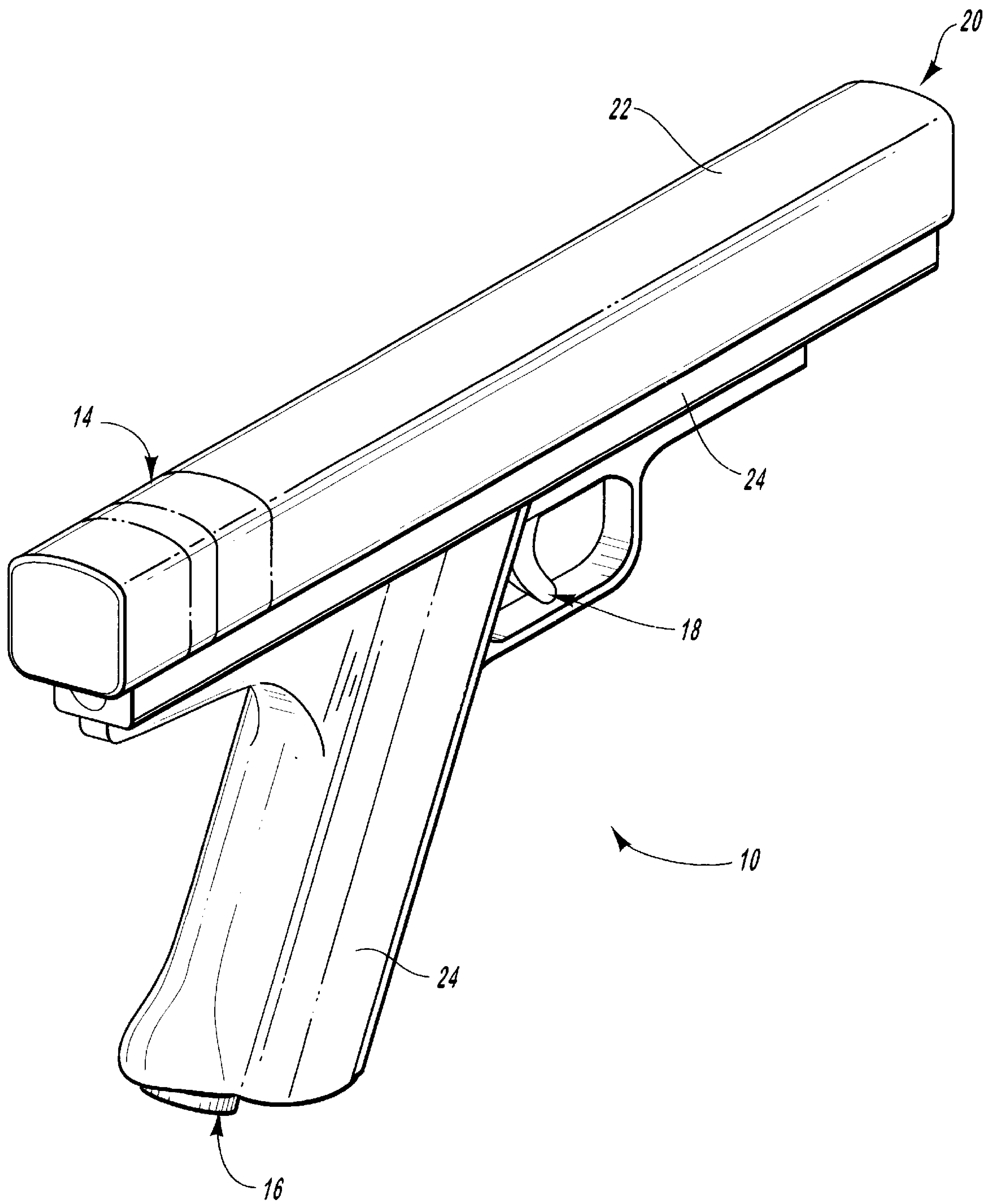


FIG. 1

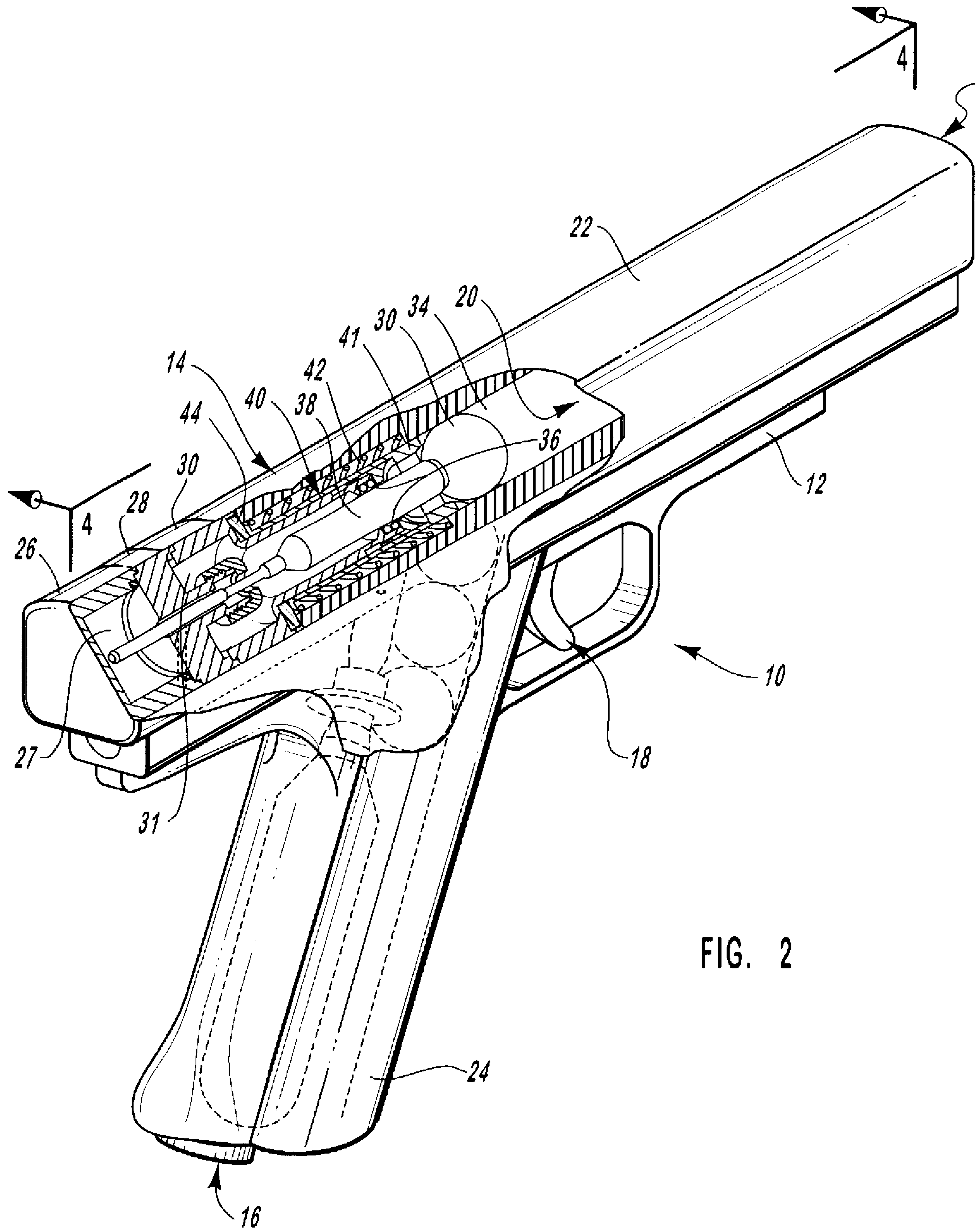

4
20
22
20
34
30
41
42
38
40
44
14
30
36
12
28
26
4
10
27
18
31
24
16

FIG. 2

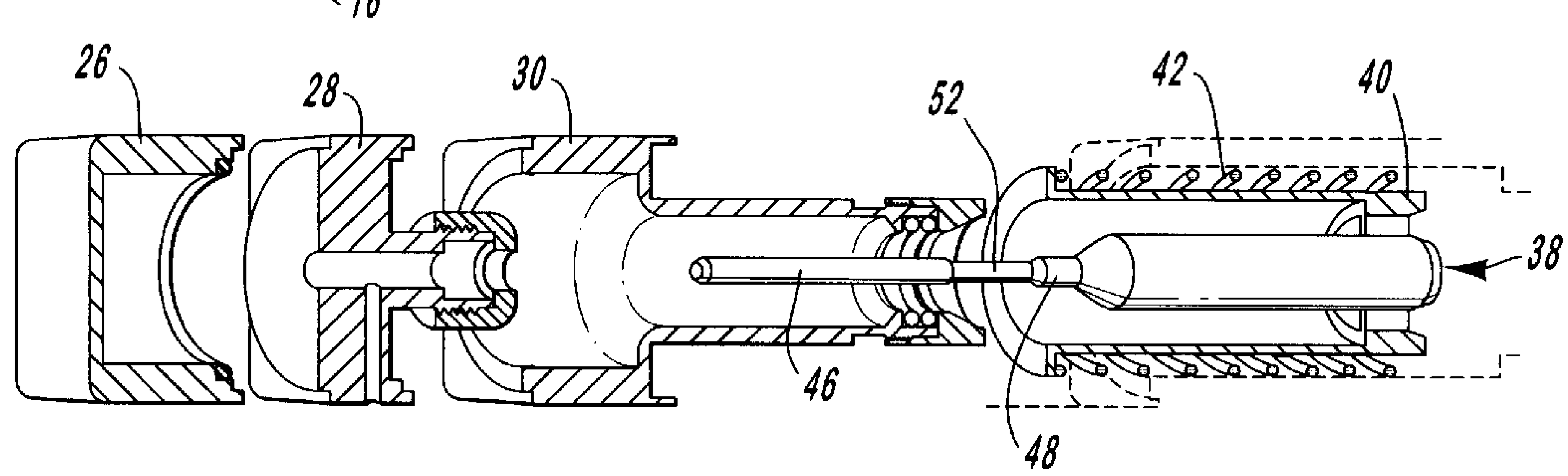

26
28
30
52
42
40
38
46
48

FIG. 3

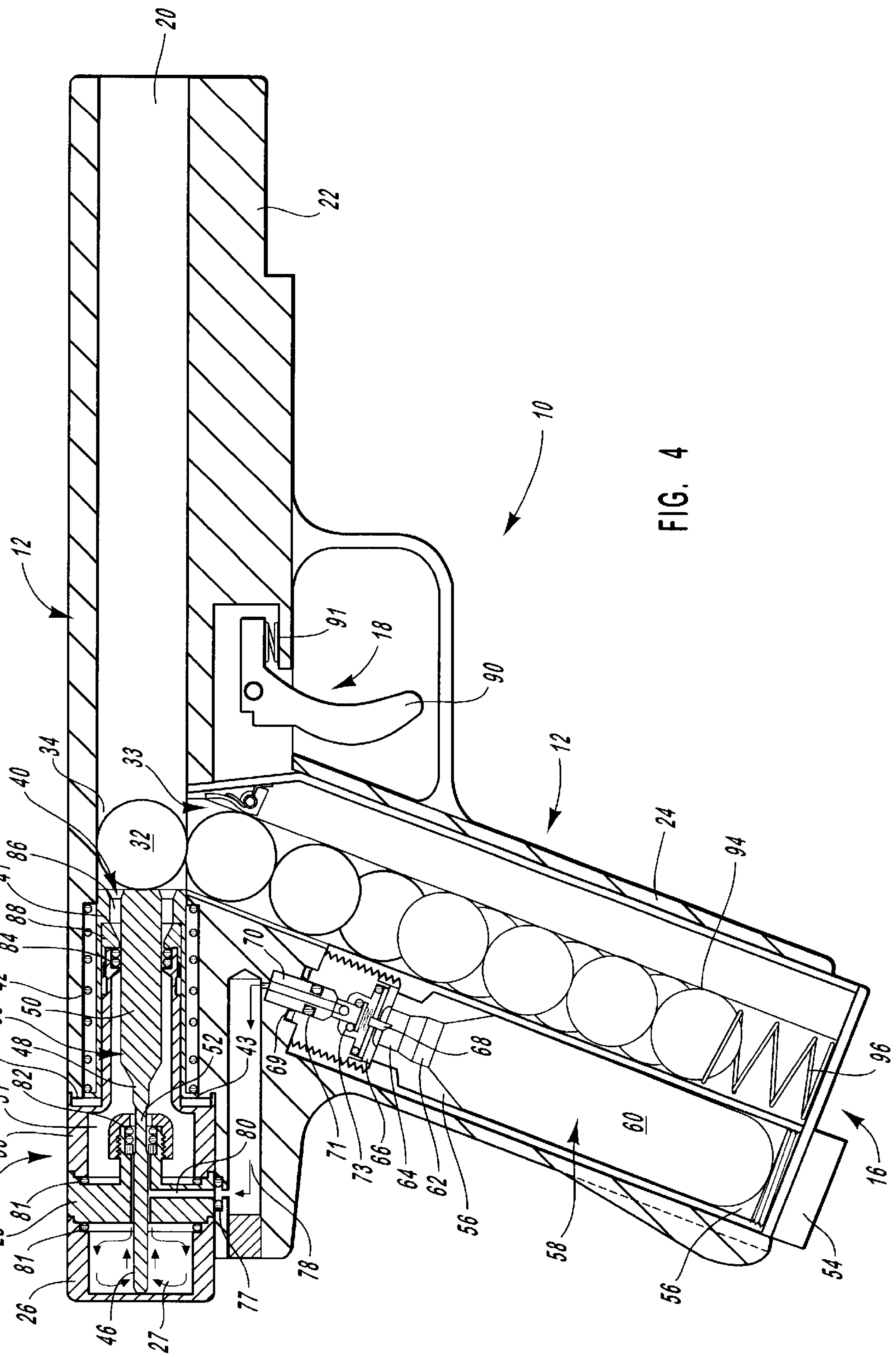

20
22
10
12
91
18
90
12
24
94
96
16
54
56
58
60
56
62
64
66
73
71
68
69
70
33
34
40
32
86
41
88
84
42
50
38
48
44
82
31
30
14
28
81
81
26
46
27
77
78
80
43
52

FIG. 4

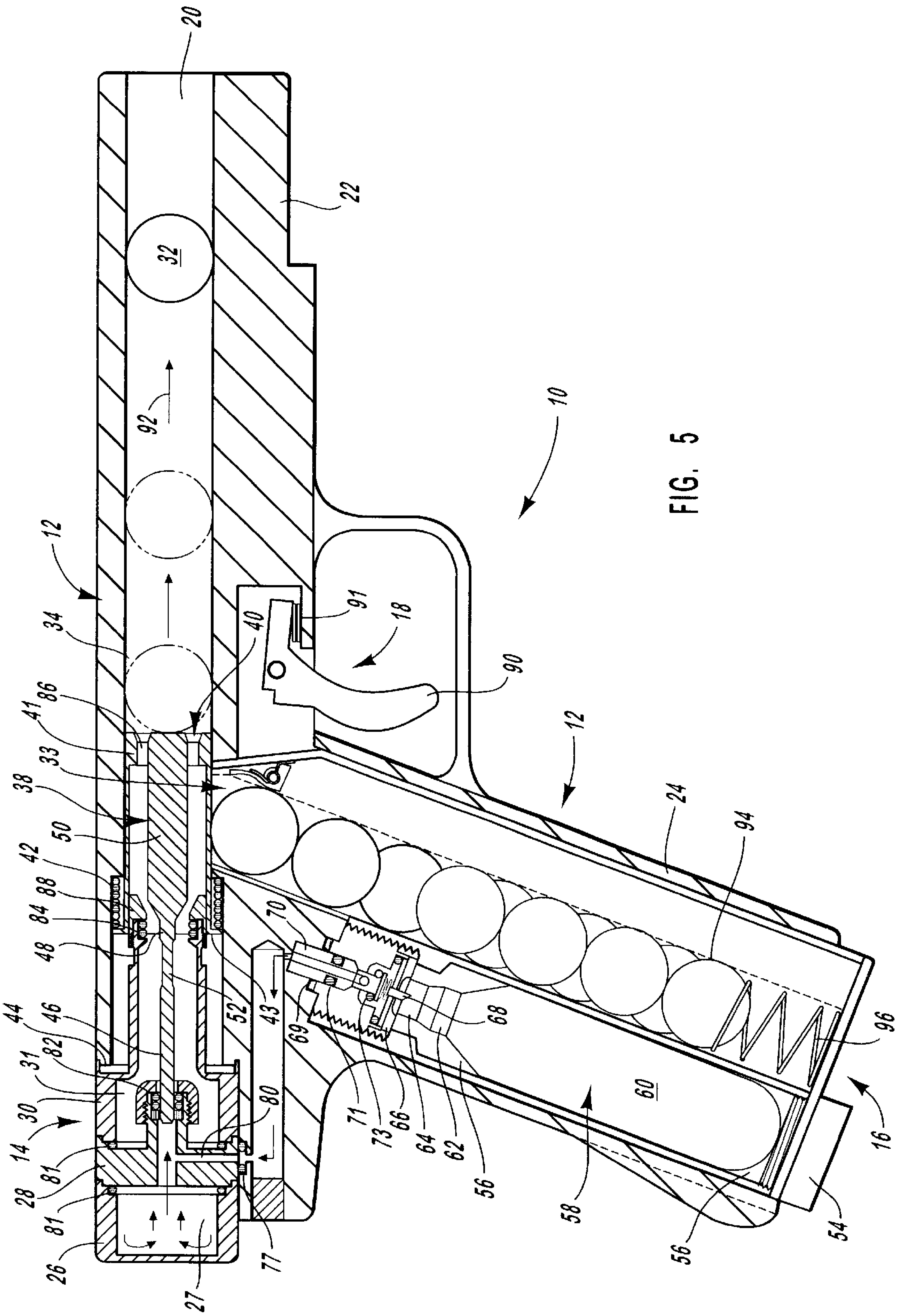

20
22
32
92
10
12
34
40
91
18
90
86
41
33
38
50
42
88
84
48
44
46
82
31
30
14
28
81
81
26
27
77
80
43
52
70
69
71
73
66
64
62
56
68
24
94
96
60
58
56
54
16

FIG. 5

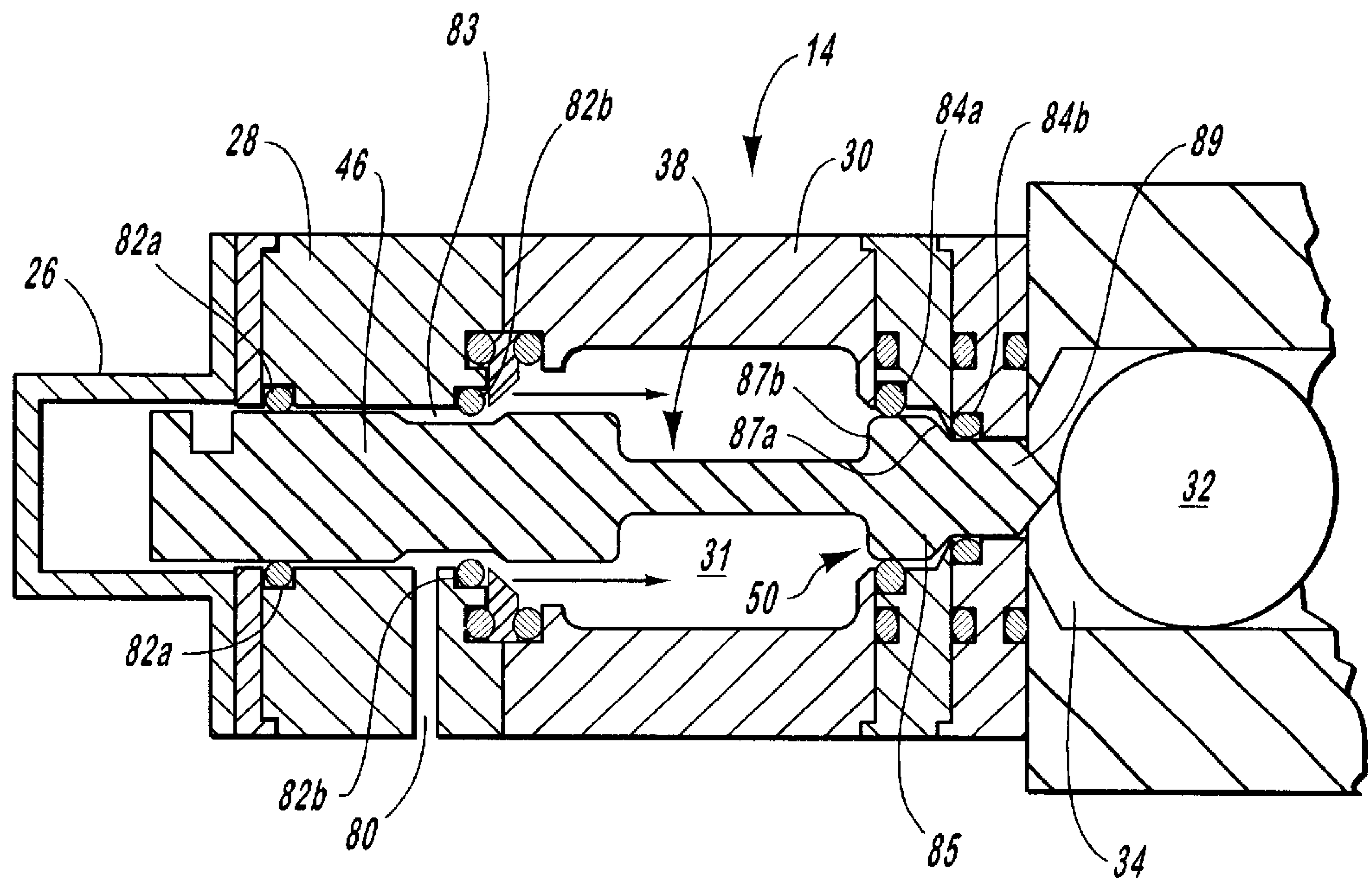

83
14
82b
28
46
38
30
84a
84b
89
82a
26
87b
87a
32
31
50
82a
82b
80
85
34

FIG. 6A

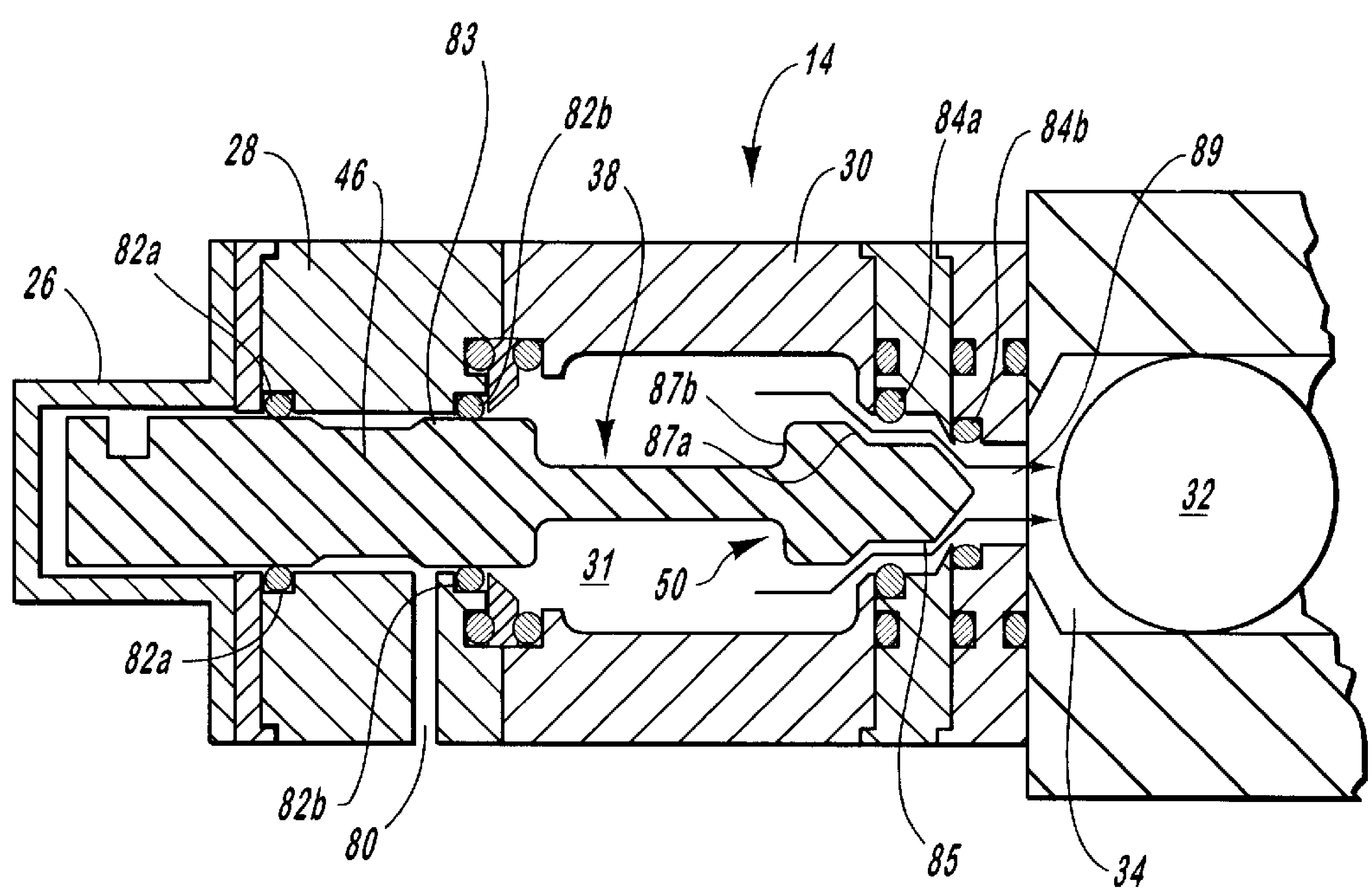

83
14
82b
28
46
38
30
84a
84b
89
82a
26
87b
87a
32
31
50
82a
82b
80
85
34

FIG. 6B

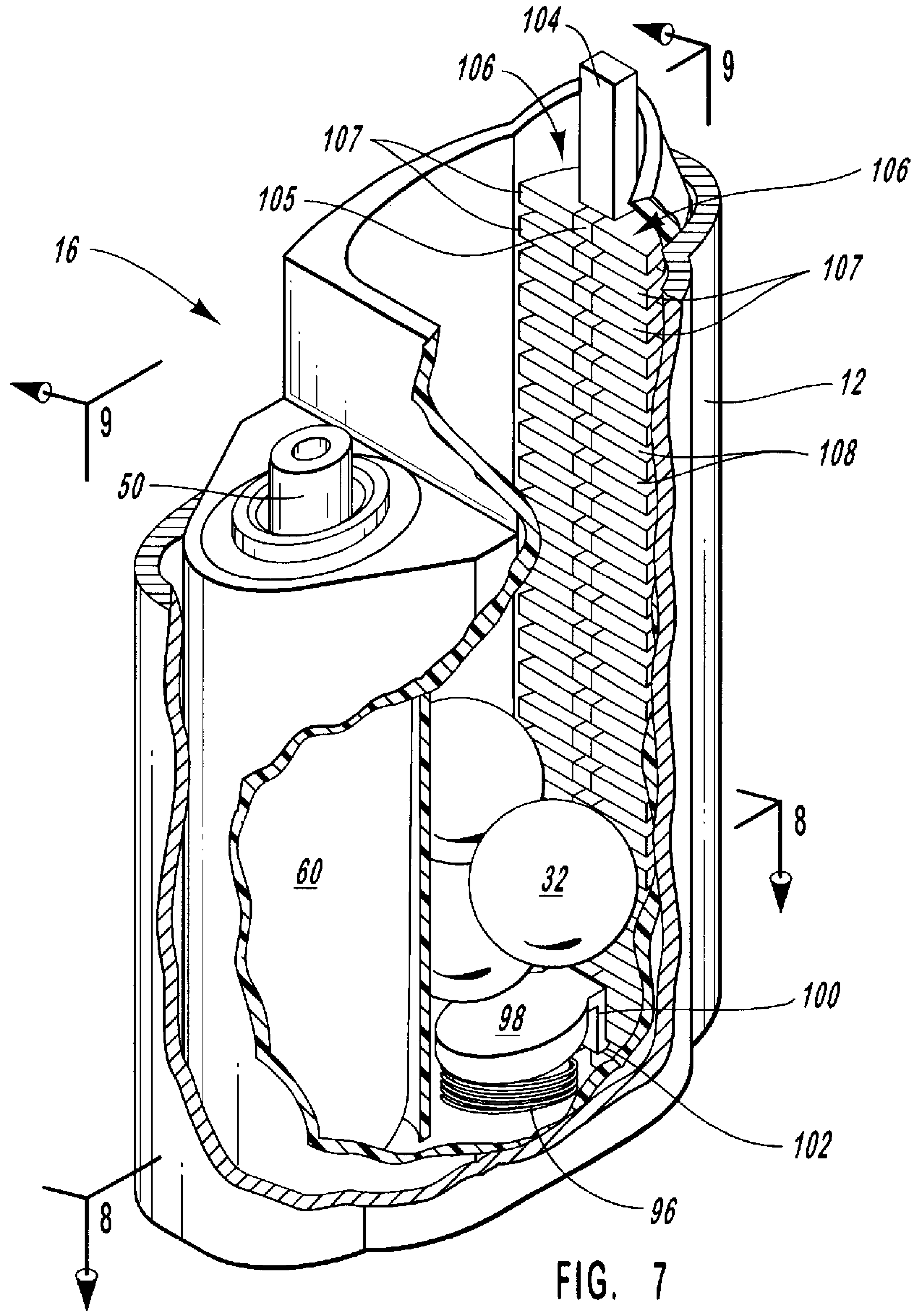

104
106
107
105
16
9
106
107
12
108
50
60
32
8
98
100
102
96
8
9

FIG. 7

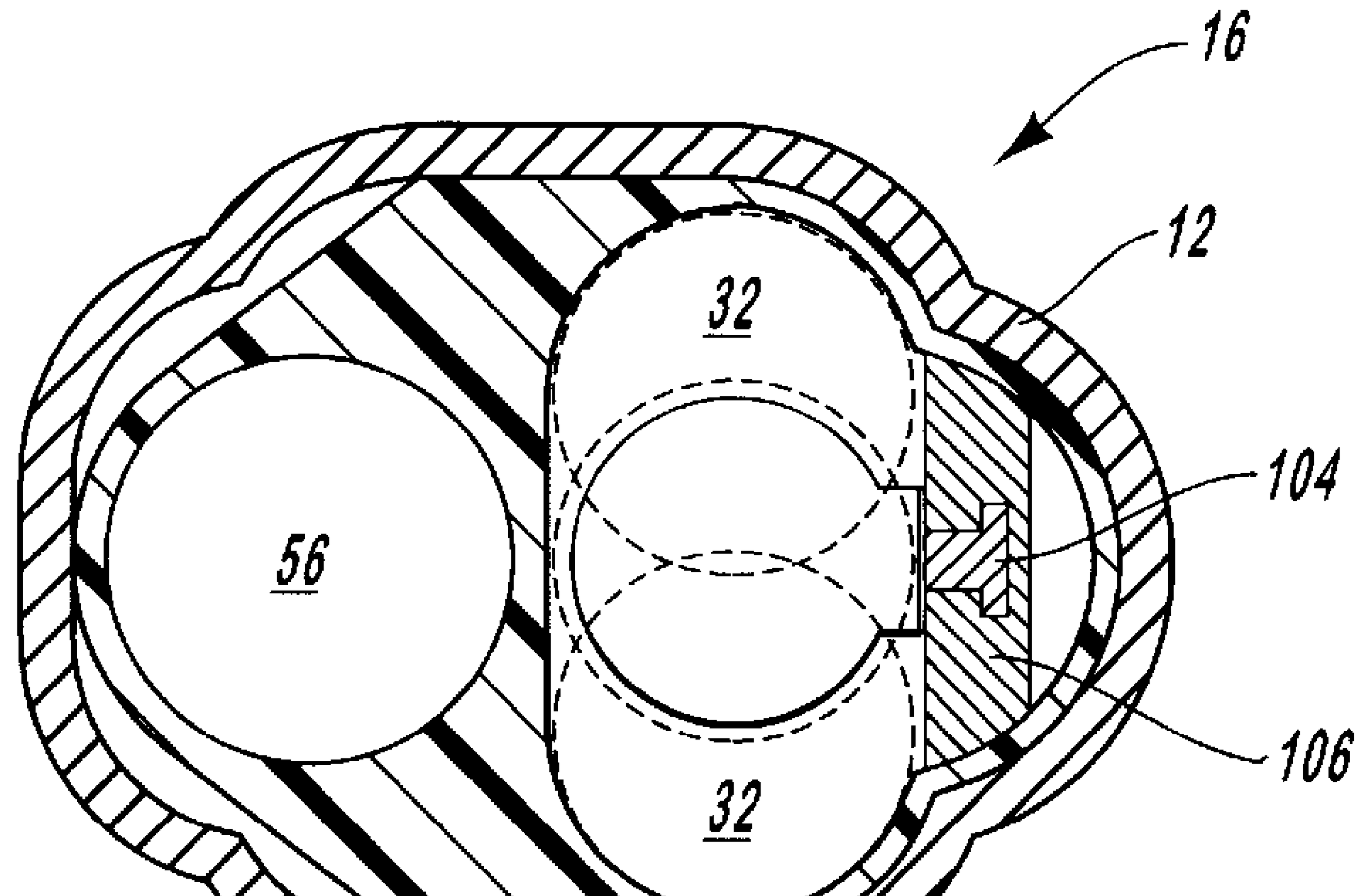

16
12
32
56
104
106
32

FIG. 8

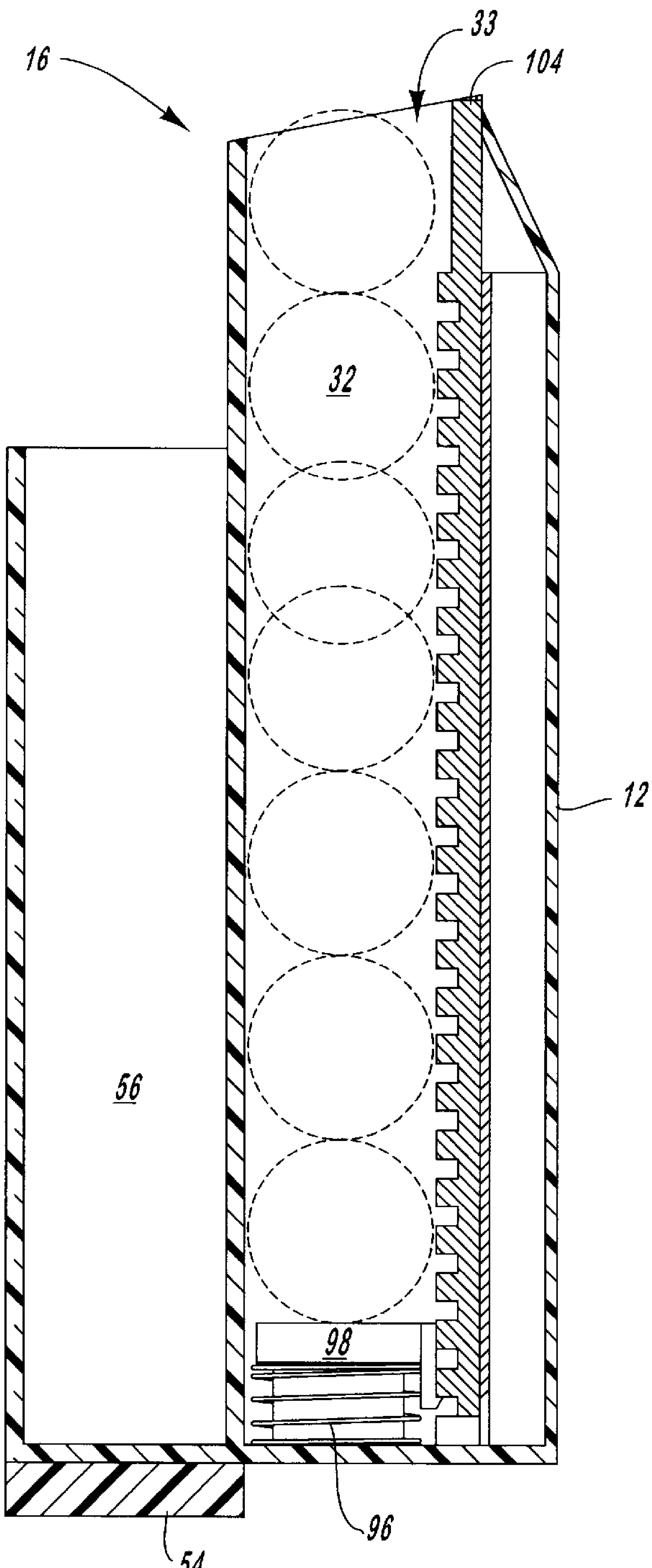


FIG. 9

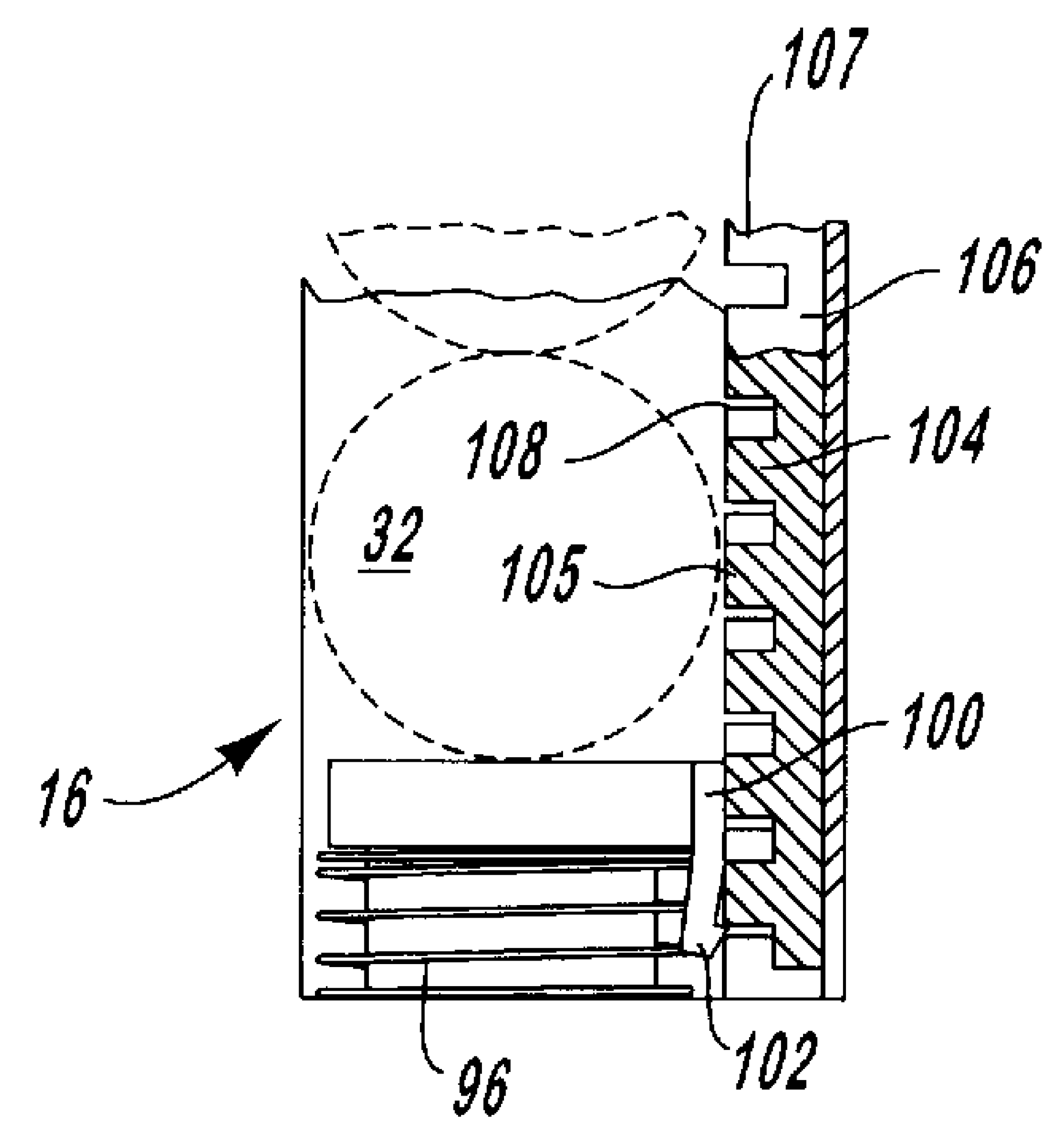


FIG. 10A

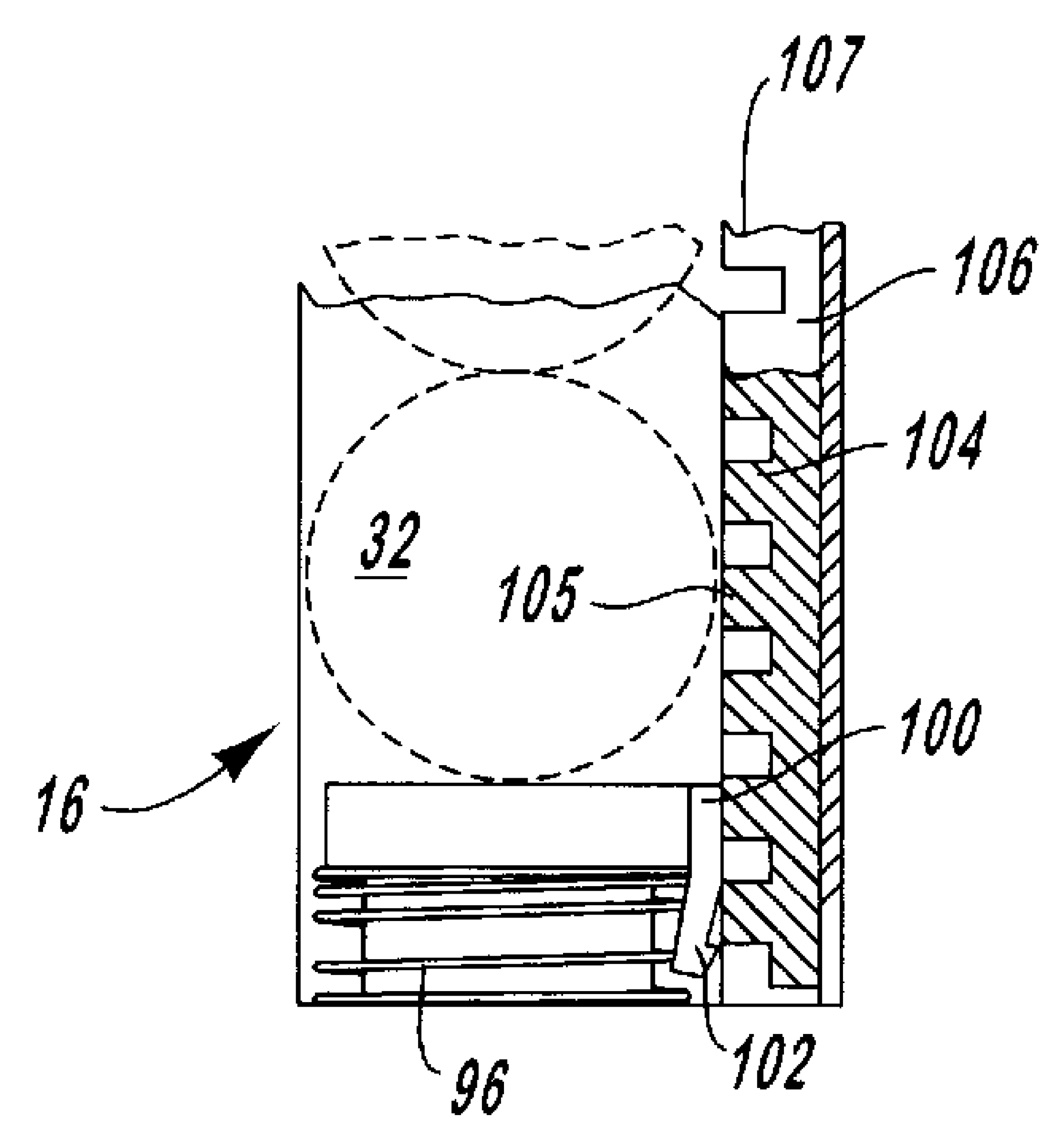


FIG. 10B

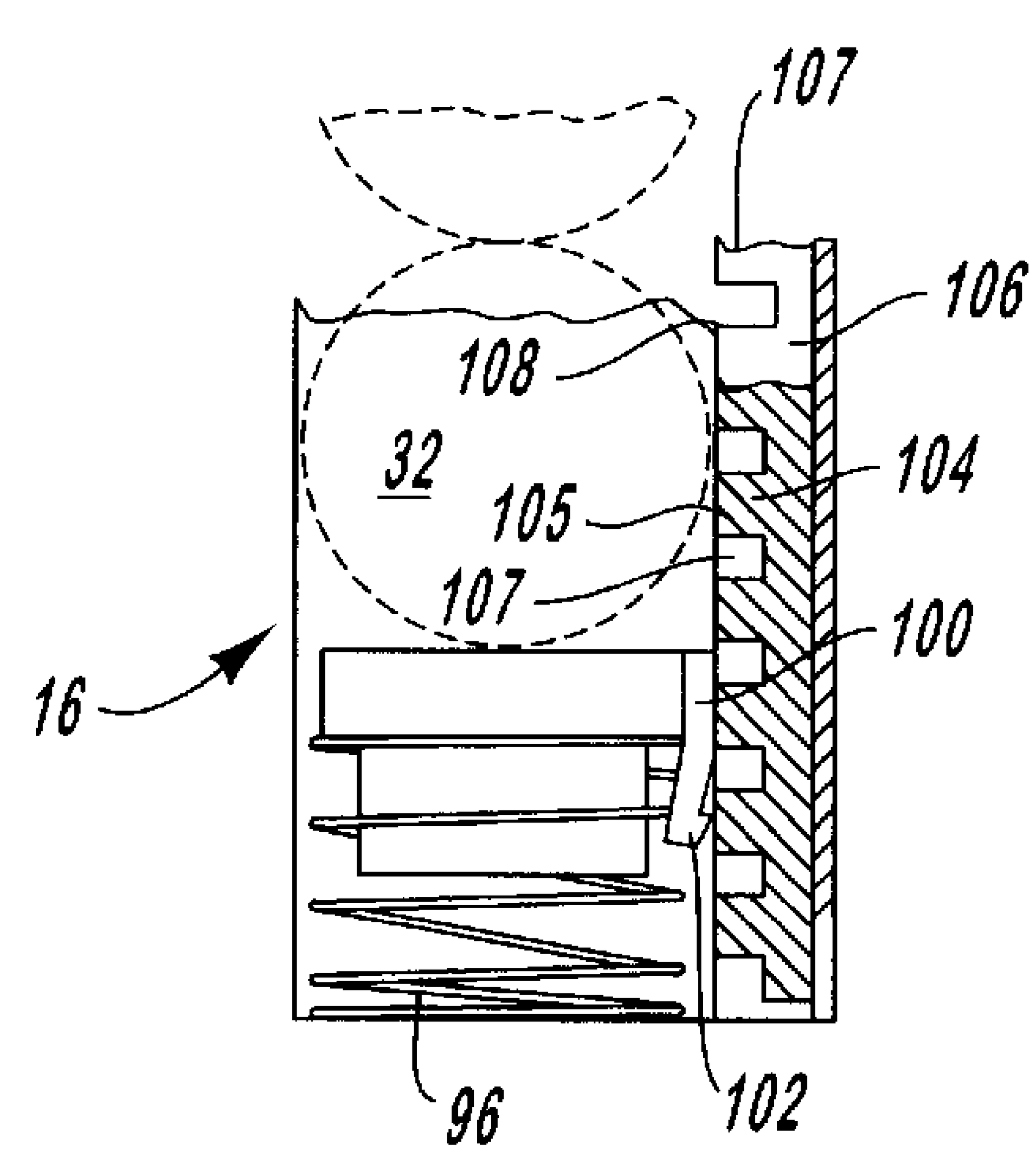


FIG. 10C

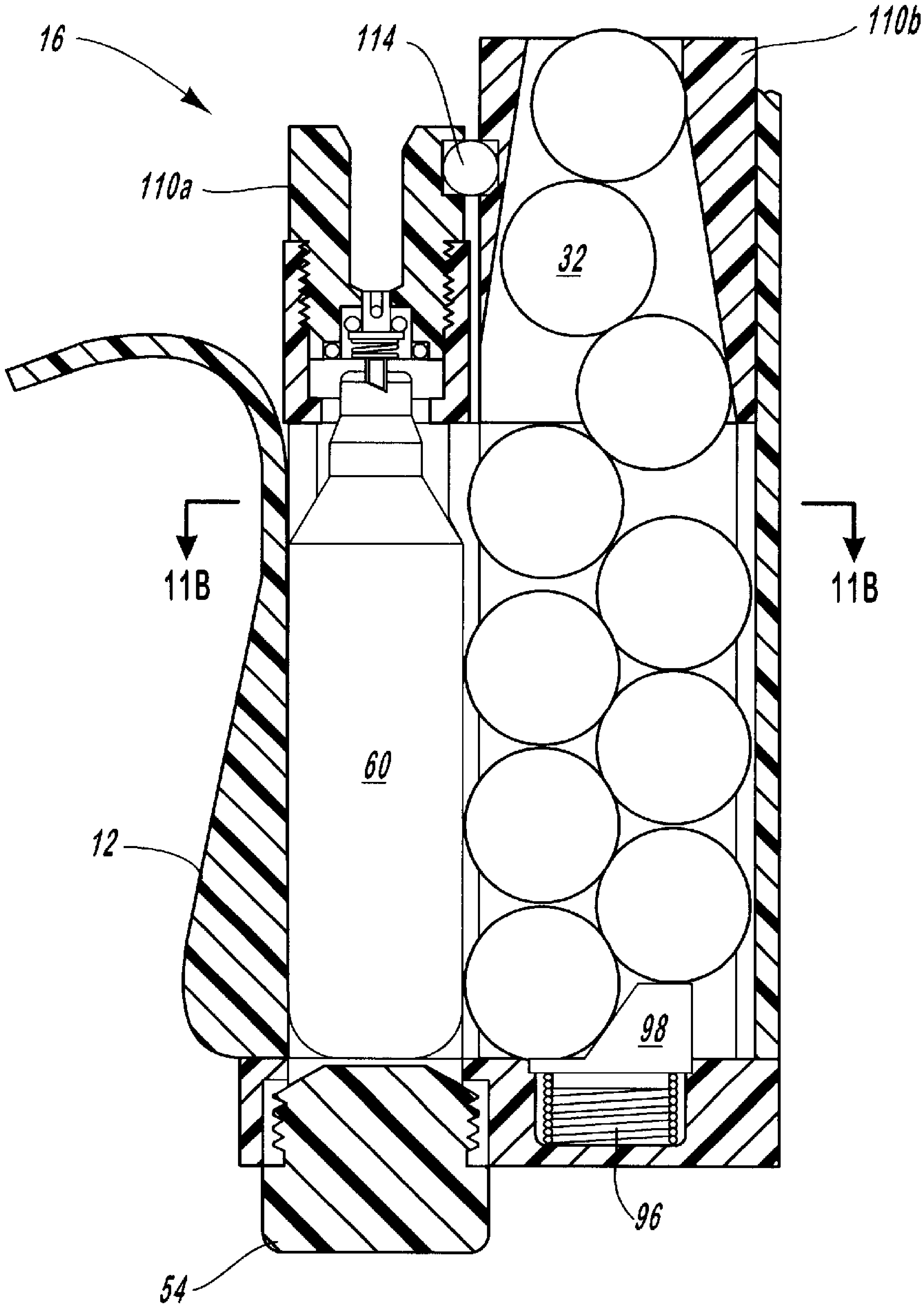


FIG. 11A

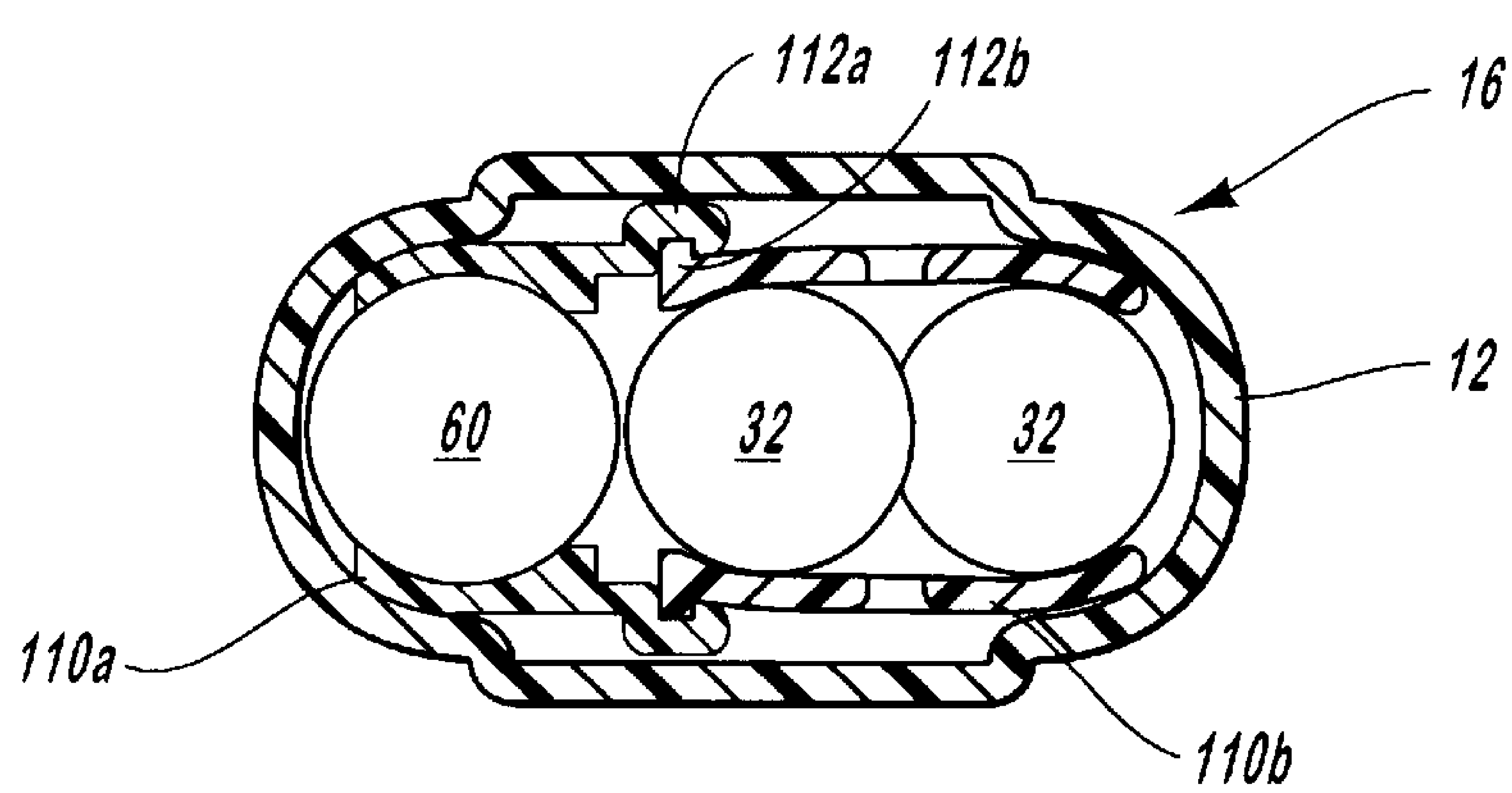


FIG. 11B

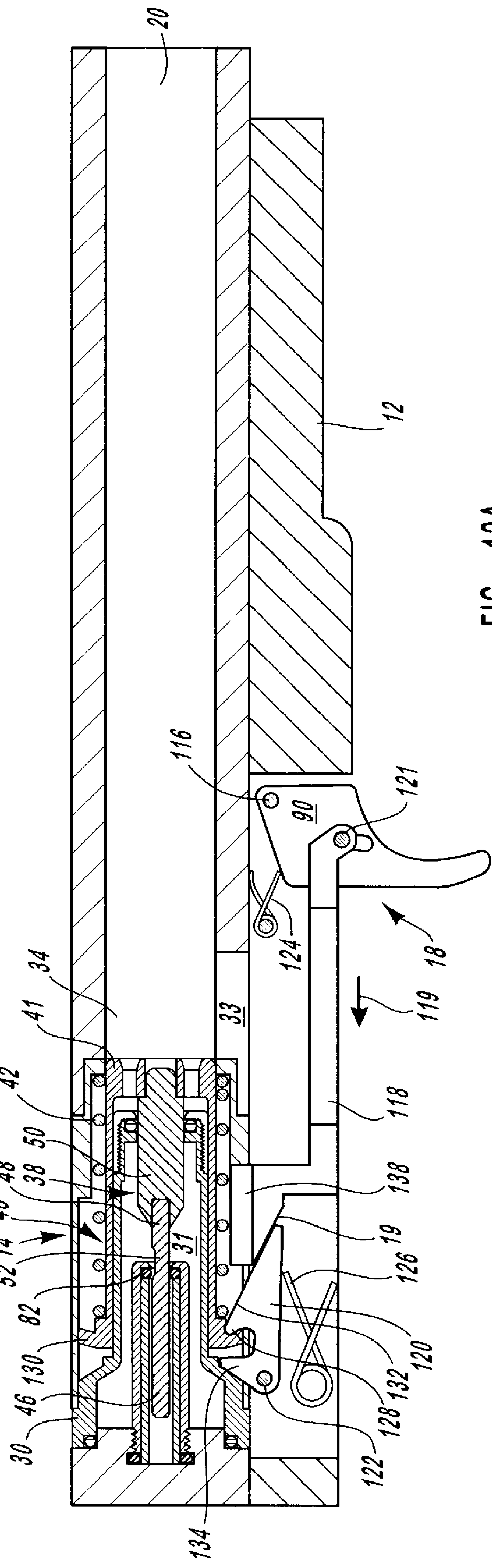


FIG. 12A

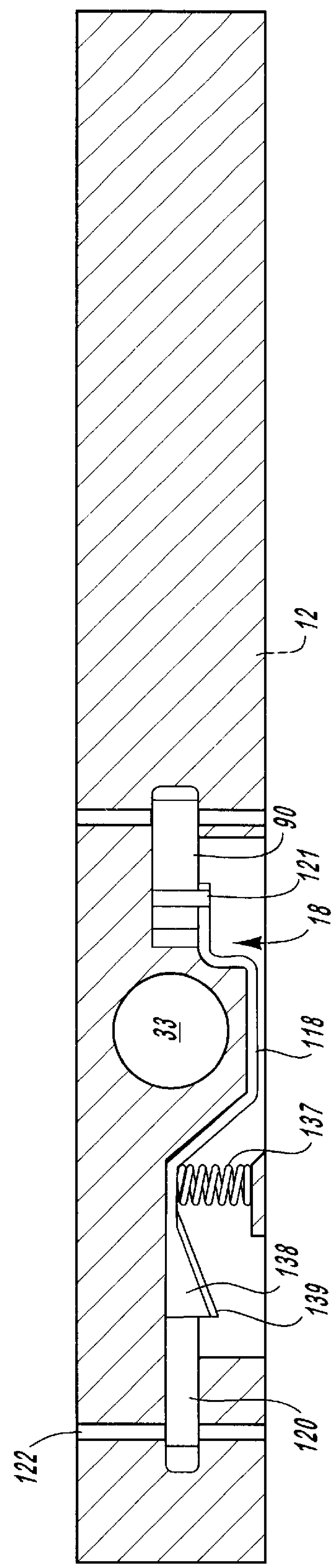


FIG. 12B

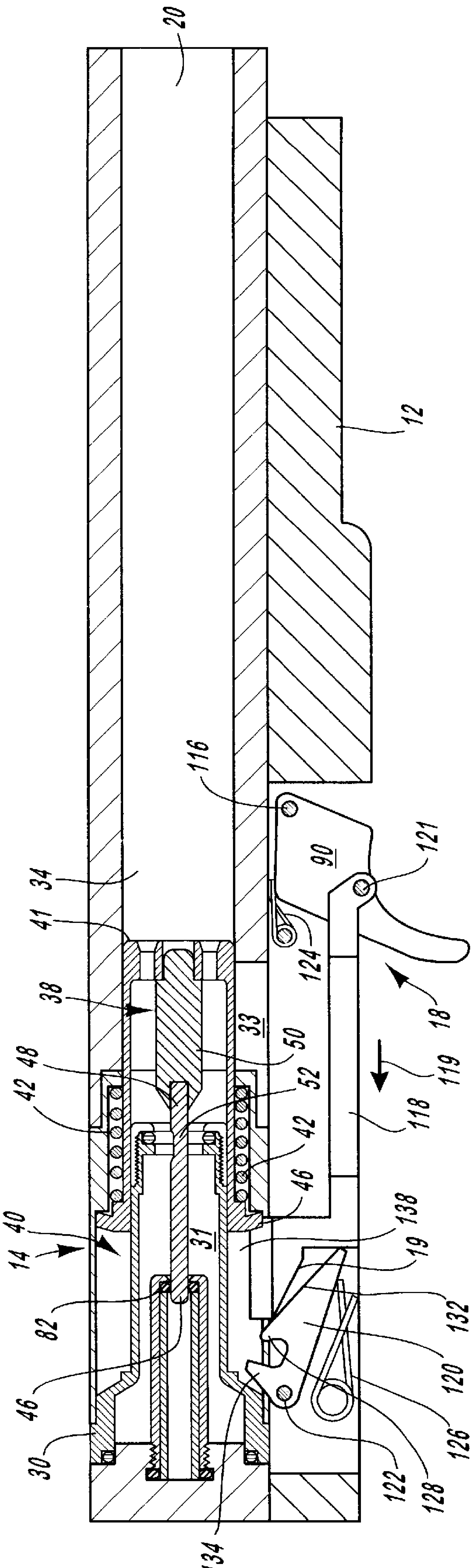


FIG. 13A

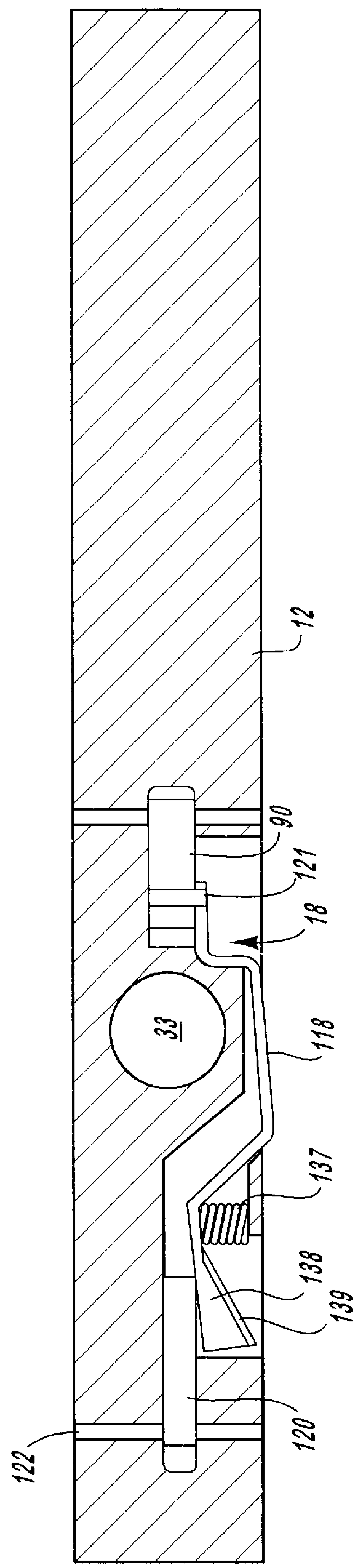


FIG. 13B

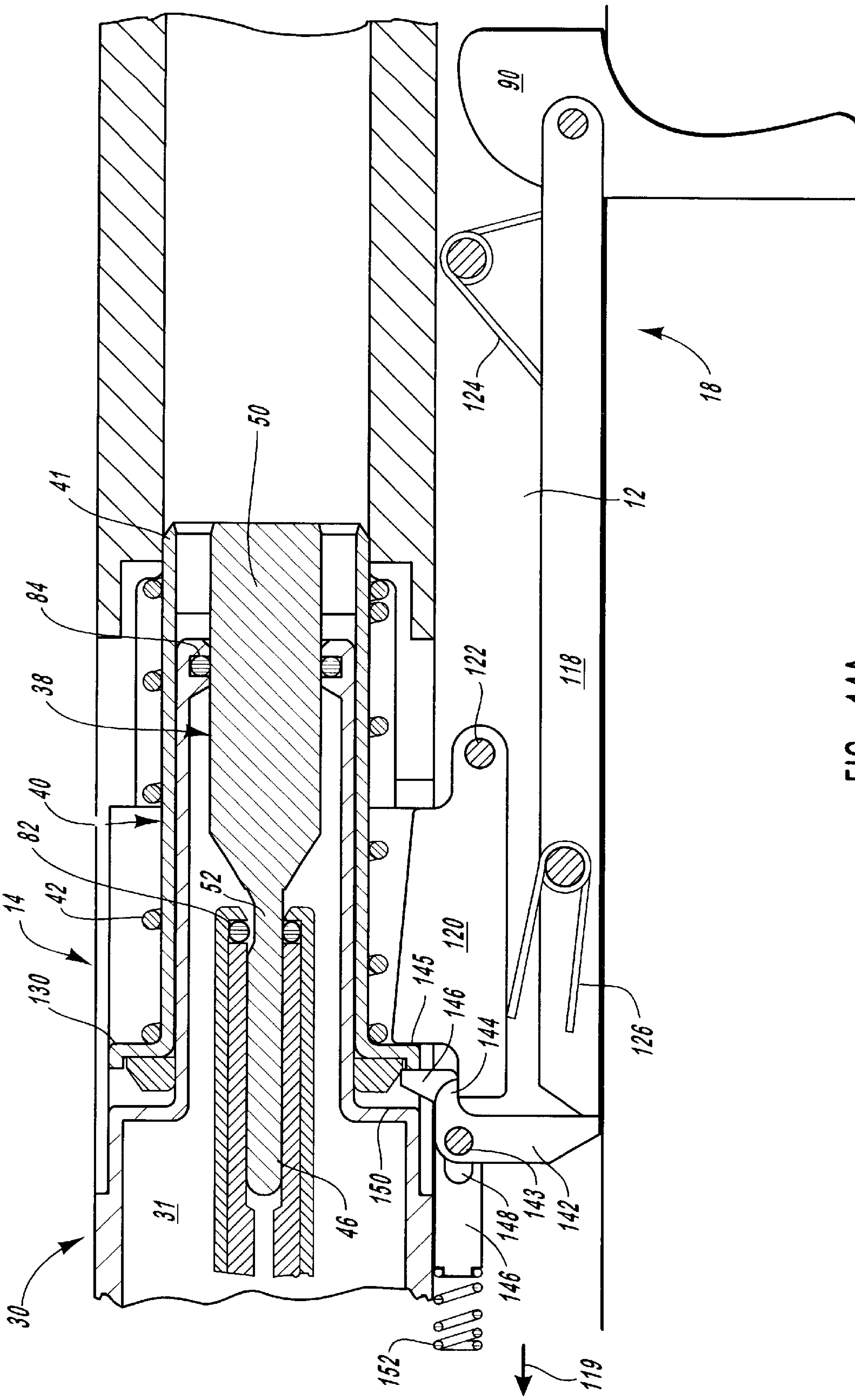

90
124
18
50
41
12
84
122
38
118
40
82
52
120
14
42
145
146
130
144
126
150
148
143
142
31
46
146
30
152
119

FIG. 14A

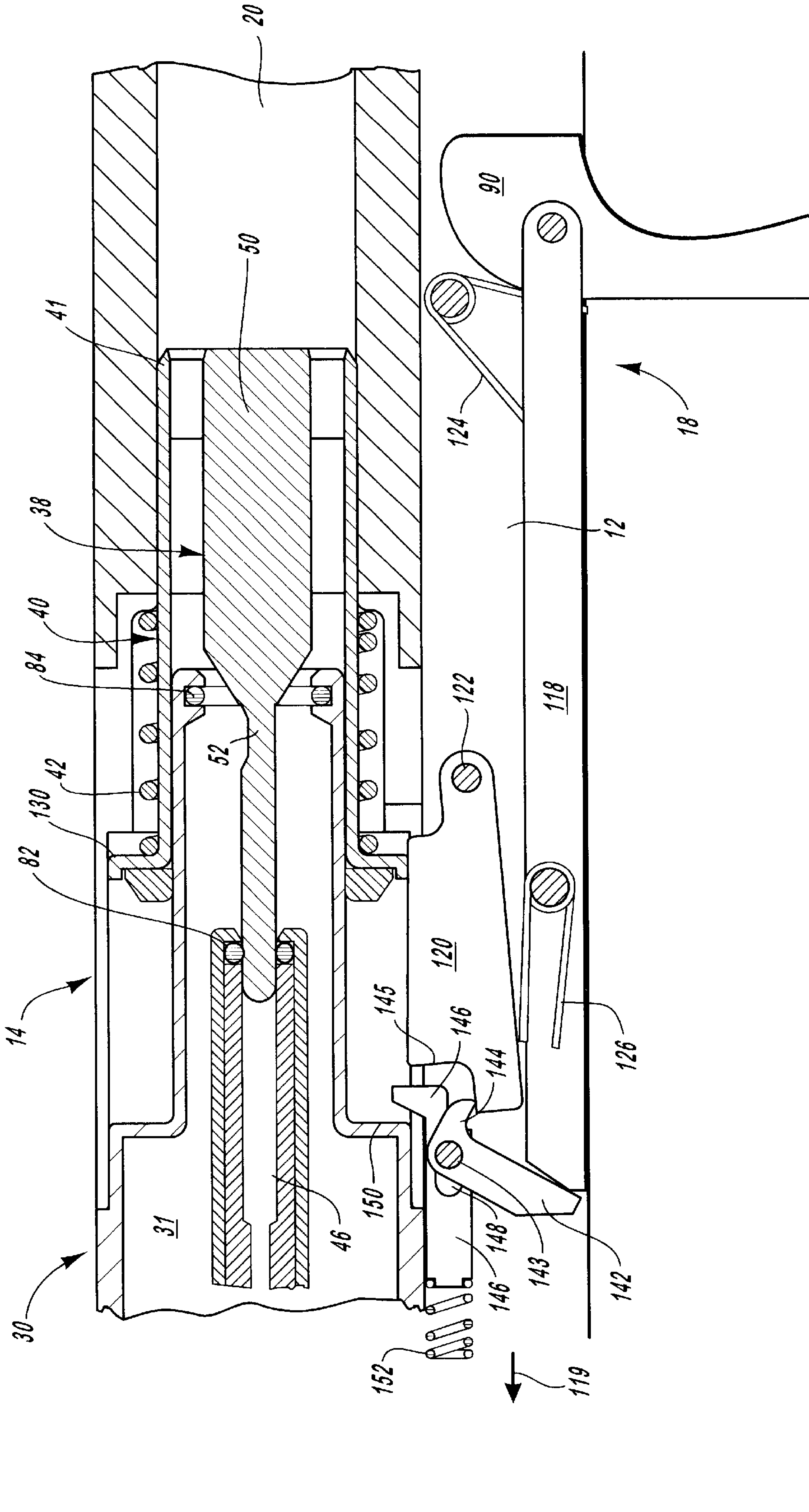

20
50
41
90
124
18
38
12
40
84
122
118
52
42
130
82
120
14
145
146
144
126
150
31
46
148
143
142
30
146
152
119

FIG. 14B

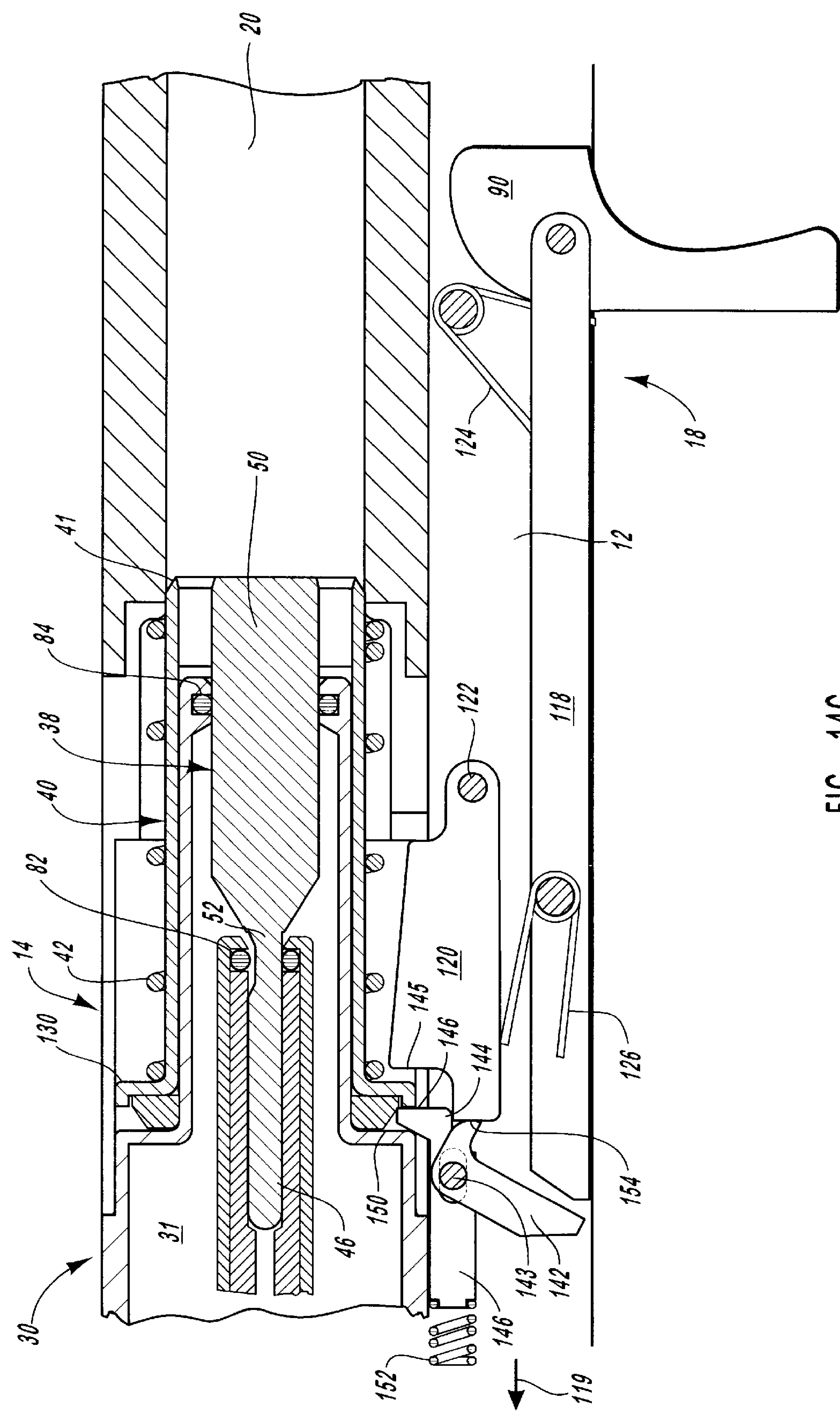

20
90
124
18
50
41
12
84
122
38
118
40
82
52
120
14
42
145
146
130
144
126
154
150
46
31
143
142
30
146
152
119

FIG. 14C

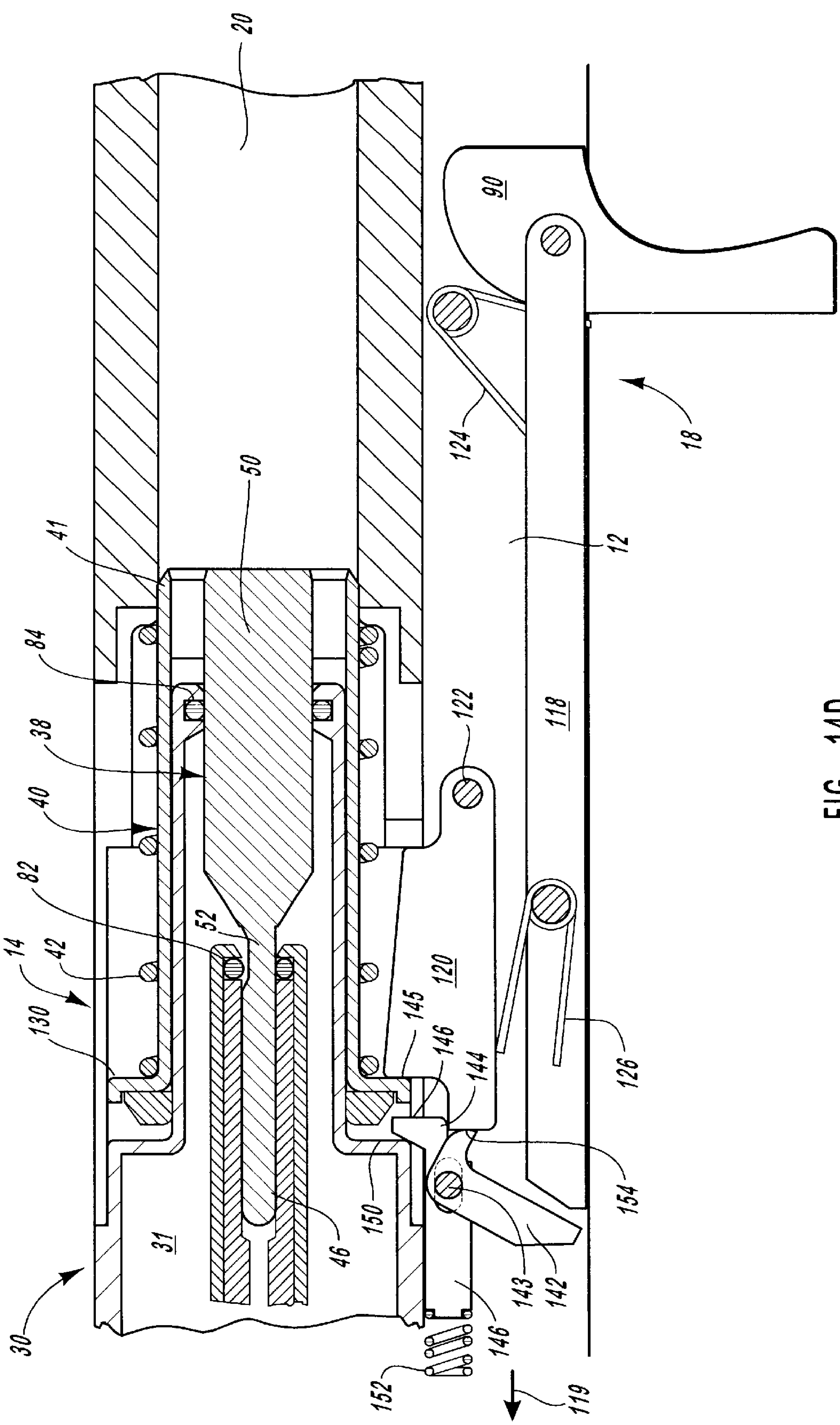

20
90
18
124
12
50
41
84
118
122
38
40
82
52
14
42
120
130
145
146
144
126
154
150
31
46
143
142
30
146
152
119

FIG. 14D

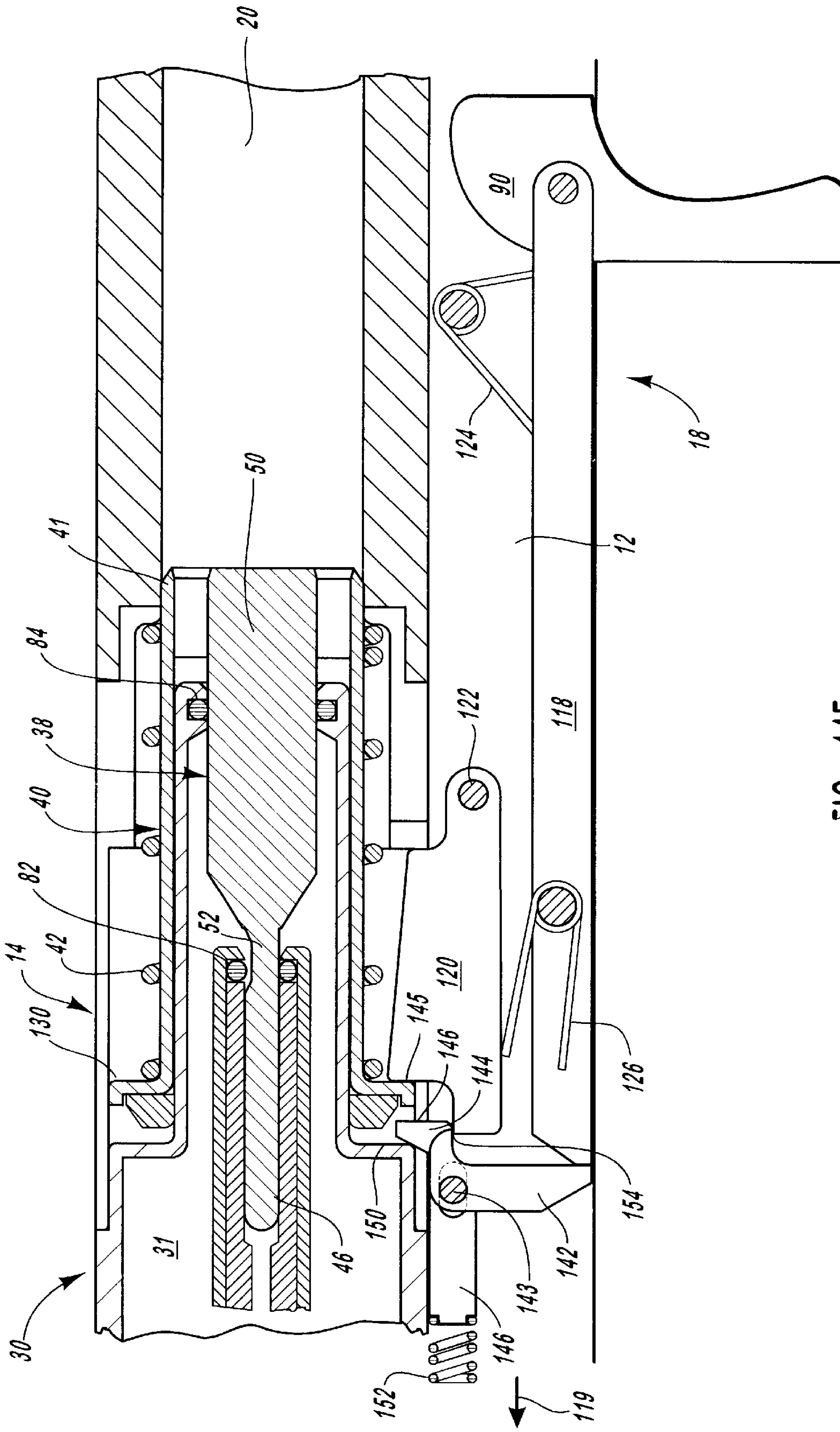

20
90
124
18
50
41
12
84
38
122
118
40
82
52
120
14
42
145
130
146
144
126
154
150
143
142
31
46
30
146
152
119

FIG. 14E

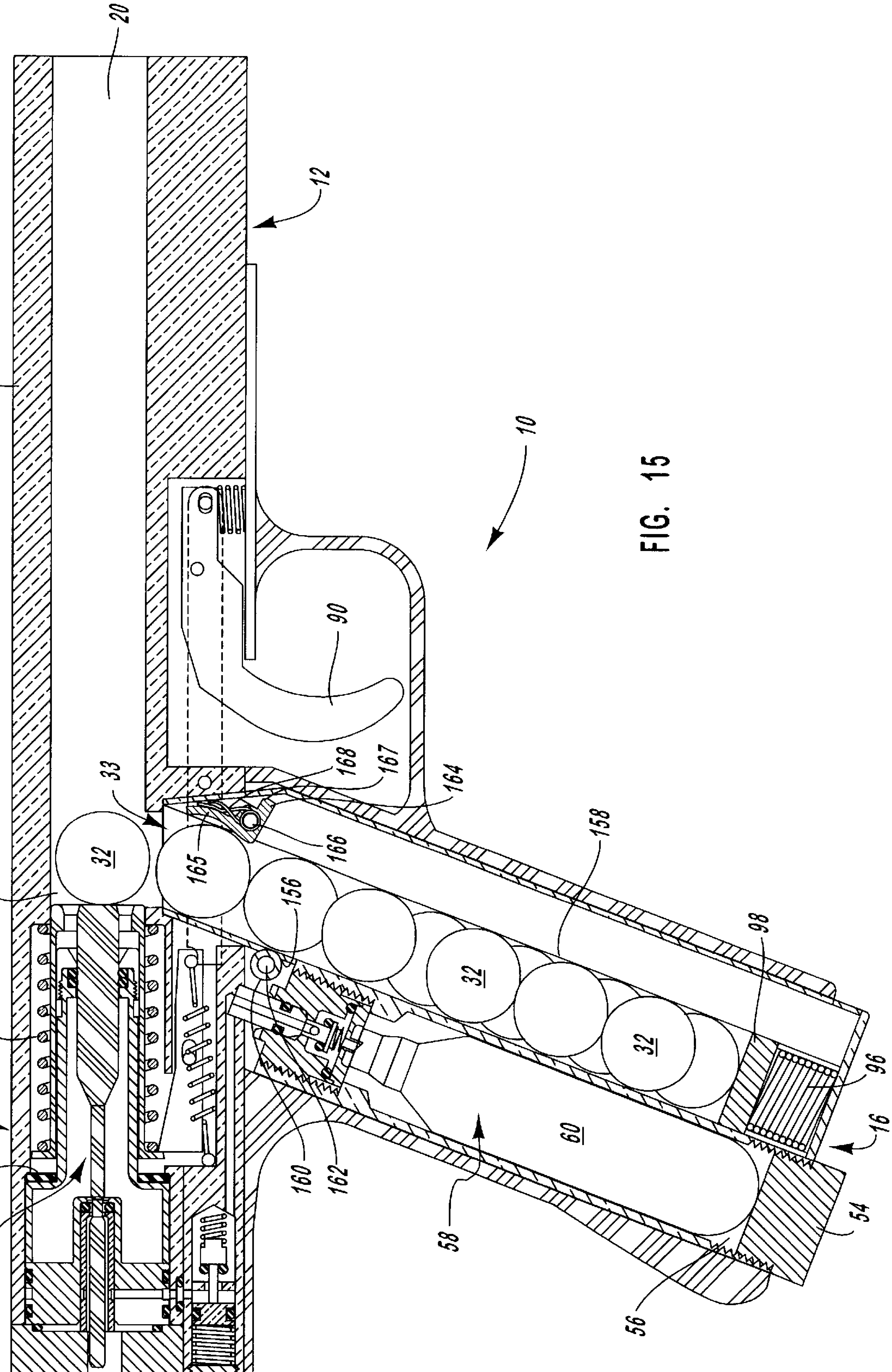

20
12
22
10
90
33
168
167
164
158
34
32
165
166
156
98
42
14
32
32
96
16
44
38
160
162
60
58
54
56

FIG. 15

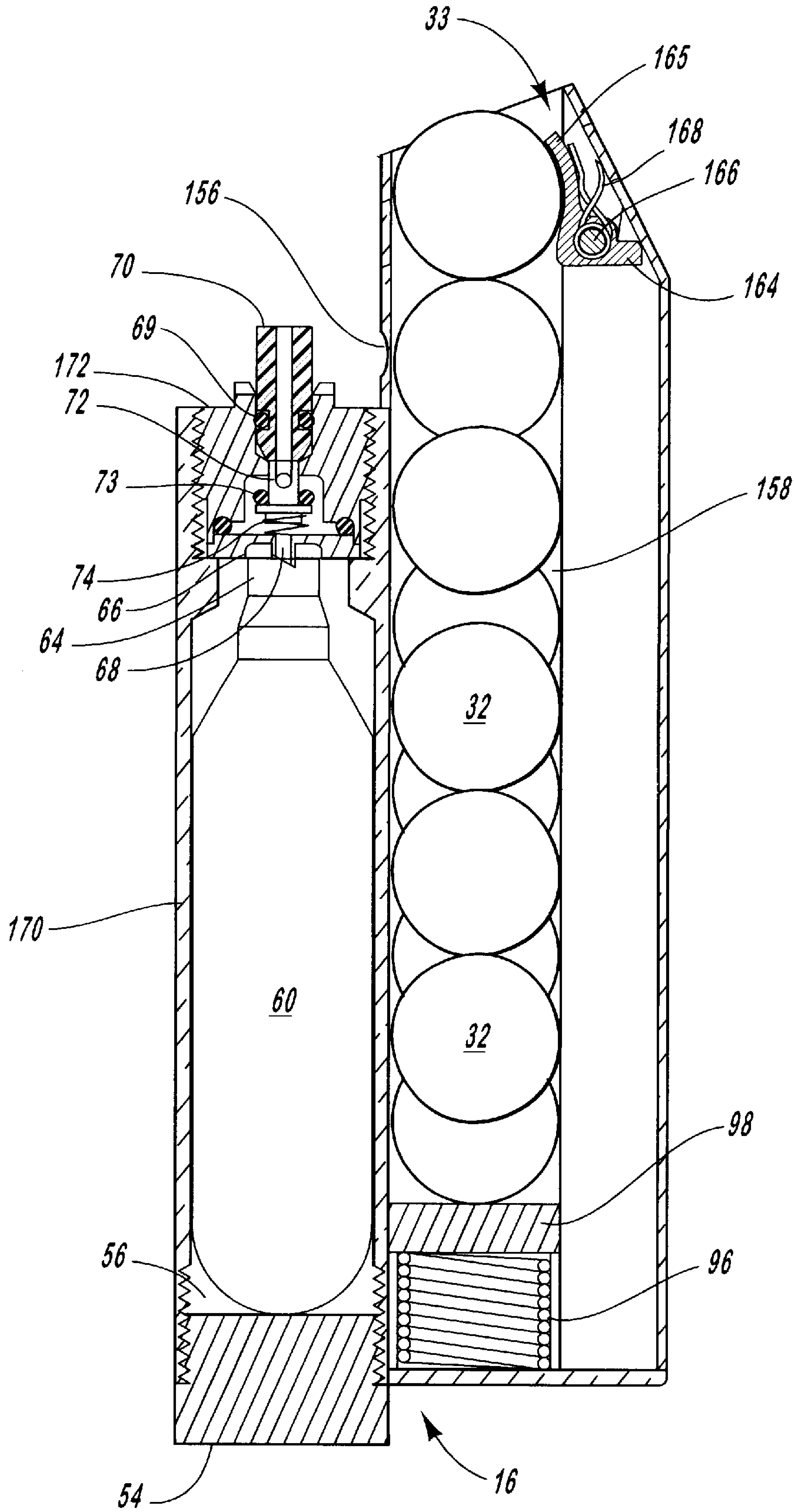
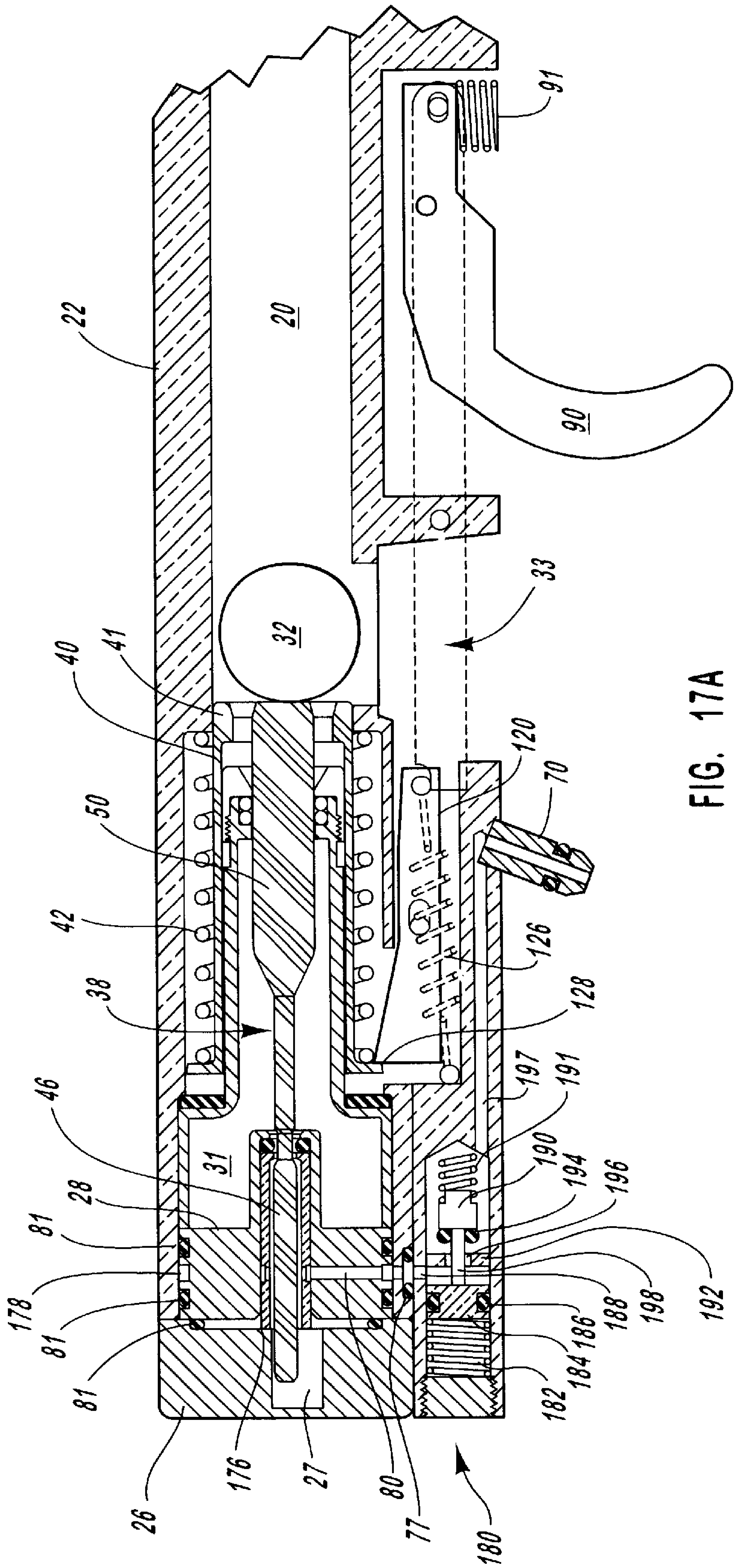

33
165
168
166
164
156
70
69
172
72
73
158
74
66
64
68
32
170
60
32
98
56
96
54
16

FIG. 16



22
20
91
90
33
32
40
41
50
42
38
46
31
28
81
178
81
81
120
70
126
128
197
191
190
194
196
192
198
188
186
184
182
26
176
27
80
77
180

FIG. 17A

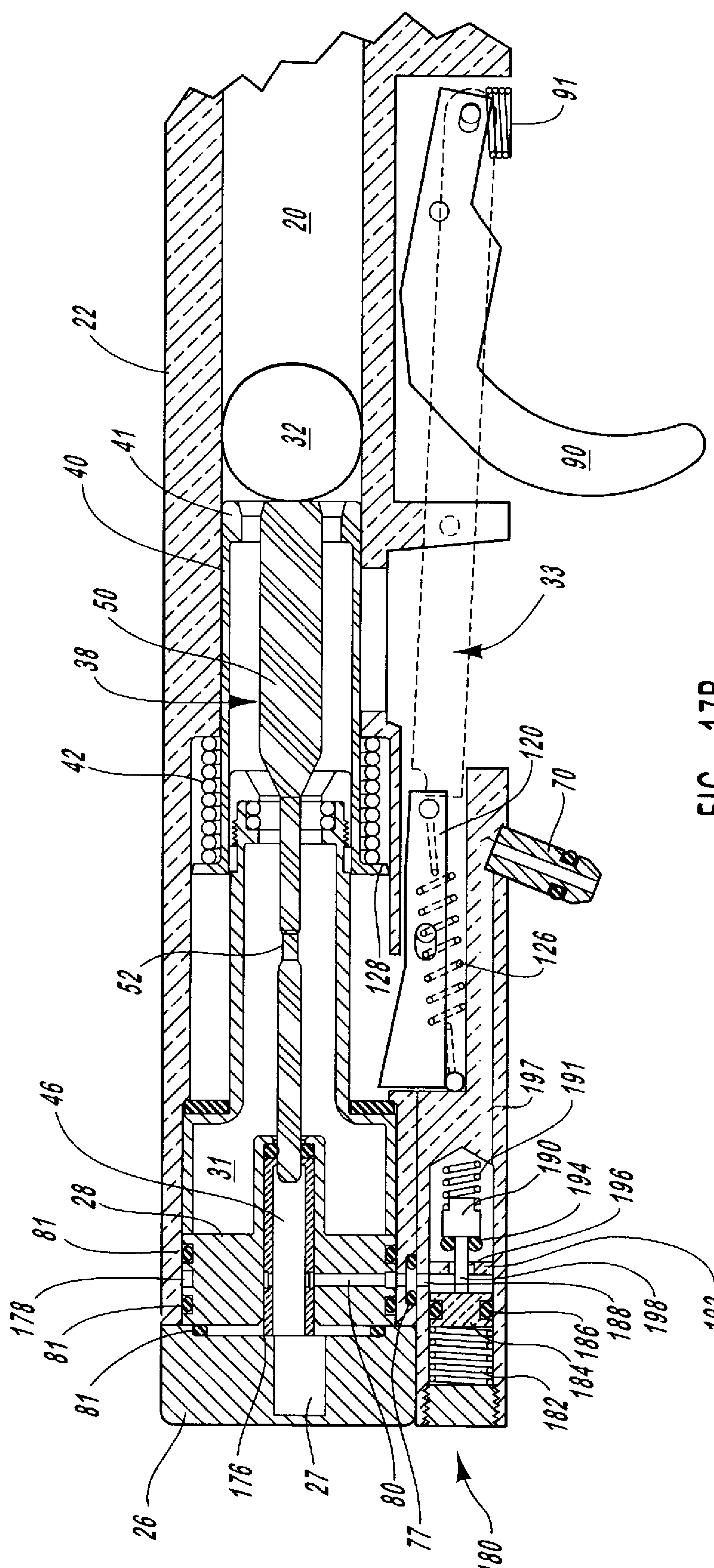

20
22
32
41
40
50
38
42
52
128
120
70
126
33
90
91
46
28
31
81
178
81
81
26
176
27
80
77
180
182
184
186
188
198
192
196
194
190
191
197

FIG. 17B

SEMI-AUTOMATIC FIRING COMPRESSED-GAS GUN

BACKGROUND

1. The Field of the Invention

This invention relates to paintball guns and, more particularly to novel systems and methods for feeding propellant and ammunition.

2. The Background Art

Paintball tag or combat has become a recreational activity favored by many players old and young. Paintball guns launch projectiles made of biodegradable, gelatinous shells surrounding a powder or paint content. Guns are carried in a manner similar to actual weapons, but typically cannot be fired as such.

Conventional paintbail guns often operate similar to a fire hose. That is, so long as a trigger mechanism is engaged, by a user, a stream of balls is fed from a large hopper into the barrel of the gun. Meanwhile, a rather unwieldy canister containing compressed gas is carried on a belt, pack, or the like, by a user, to be released in a stream by a trigger. Accordingly, paintball guns appear to operate more like hoses than guns. Very little control is available over the expenditure of paintballs and compressed gas. Moreover, accuracy, conservation of ammunition, handling, and the like, are not similar to the same functions for conventional weapons. Moreover, the segregation of the gas supply and launcher (gun) tends to interfere with the overall sense of balance, operation, utility, aiming, and the like for paintball weapons.

What is needed is a paintball gun designed to look, feel, weigh, and operate very similarly to an actual weapon. Thus, integration of a gas supply within a weapon, making ammunition clips reloadable and exchangeable in a reasonable size, triggering, maximum loads, and so forth are all objectives to be met by a paintball gun suitable for replicating or approaching actual weapons.

Mechanisms for operating paintball guns may be designed in a variety of ways. One may design a lock or action of a gun to use gas from a compressed gas source to discharge projectiles. Another quantity of the same compressed gas may be used to actuate a firing mechanism, returning a trigger and actuation system to a ready-to-fire position.

One may also use a trigger mechanism to actuate multiple mechanisms. A trigger may actuate a valving system controlling and directing the flow of compressed gas as a propellant. Similarly, a gun trigger may provide catching and releasing a feed mechanism for paintballs.

What is needed is a mechanism for providing a firing bolt. The firing bolt should simultaneously control delivery of gas, including any porting, discharge, sealing, and the like, while also loading a projectile into a barrel for firing. It would be an advance in the art if a mechanism could be designed such that upon firing, a bolt automatically returns to a ready-to-fire position by virtue of a return mechanism other than consumption of additional compressed propellant.

It would be a further advance in the art to provide a gun trigger with a function requiring only selected catching and releasing of such a firing bolt. In such a mechanism, compressed propellant (e.g. gas) could be used for the single purpose of firing the projectile, with loading occurring automatically as part of the sequence. Thus, the entire mechanical workings of a gun may be greatly simplified while the efficiency of use of compressed propellant would require smaller containers therefor.

It would be a major advance in the art to combine an ammunition magazine in a single "clip." Prior art systems contain a plumbing apparatus for storing compressed propellant and delivering it to a launcher (e.g. gun), operating much like a hose or piping system.

Meanwhile, massive hoppers drain a seemingly unending stream of paintballs into the flow path of the gas, launching them like so many beads in a chain. It would be a substantial advance in the art to provide a gun having sufficiently small requirements for propellant that a compact canister of propellant could be carried and maintained within the envelope typically associated with a conventional gun magazine. Moreover, it would be a major advance in the art to combine a clip of projectiles and compressed propellant into a single magazine, providing for quick reloading of the entire magazine with a single set of coordinated motions. Thus, having a clip or magazine containing both propellant and projectiles would be more nearly replicate the experience of loading and firing a conventional weapon. Thus, such an improved device may be most beneficial in training and simulation for law enforcement agencies.

BRIEF SUMMARY AND OBJECTS OF THE INVENTION

In view of the foregoing, it is a primary object of the present invention to provide an apparatus and method for launching projectiles using a compressed gas as a propellant, the entire apparatus being sized and operable consistent with conventional guns.

It is an object of the invention to provide an apparatus and method in which an integrated magazine and gun are provided within the envelope conventionally associated with actual guns.

It is an object of the invention to provide a simplified trigger actuation apparatus and method tending to operate a gun in a manner consistent with conventional guns.

It is a further object of the invention to provide a ready mechanism for replacing magazines.

It is a further object of the invention to provide a magazine that integrates propellant and projectiles in a unit that can be handled by a user in a manner consistent with conventional guns.

It is an object of the invention to provide careful control of gas discharge from a propellant reservoir in order to reduce the requirements for propellant, and thus reduce the size of a propellant source required for an apparatus and method in accordance with the invention.

Consistent with the foregoing objects, and in accordance with the invention as embodied and broadly described herein, an apparatus and method are disclosed, in suitable detail to enable one of ordinary skill in the art to make and use the invention. In certain embodiments an apparatus and method in accordance with the present invention may include a gun having a firing bolt. The firing bolt may be propelled down range within the gun by air pressure or other propellant from an air or gas chamber.

A catch may hold the firing bolt against moving, thus locking the bolt into a ready-to-fire position until activated by a trigger. In certain embodiments, a bolt catch may engage a matched portion of a firing bolt to lock a bolt in place. Upon actuation of a trigger, the firing bolt disengages from the catch, freeing the bolt to travel down range as a firing mechanism of the gun. Also, upon movement of the bolt forward, a valving mechanism associated with the bolt releases gas urging the bolt forward, the gas passing through the bolt and into the barrel of a gun, accelerating a projectile (e.g. paintball) down the barrel.

In certain embodiments, a system of springs and catches returns the bolt and trigger mechanisms to their original, ready-to-fire positions. In certain embodiments, an ammunition magazine may contain a canister or cartridge holding compressed gas or other propellant (e.g. liquid, saturated liquid, or gas) maintained under pressure for propelling projectiles from the gun. In certain embodiments, a magazine may be removable from the gun without discharging remaining propellant from the storage cartridge.

In alternative embodiments, the magazine may be designed to operate as a single, monolithic unit, yet to be separable between the propellant and the projectiles. For example, a carbon dioxide cartridge may be used, and will typically contain 12 grams of carbon dioxide. About 25–30 rounds of ammunition may be fired with 12 grams of carbon dioxide. However, a magazine for a pistol is usually stored in the handle of the gun. In such a configuration, space constraints may limit a magazine to approximately 10 rounds of projectiles. In order to effectively use all of the available propellant, a user may remove the magazine and reload the projectiles approximately three times for each reloading of a propellant cartridge. In one embodiment, the entire magazine may be retrieved from the gun and the propellant may automatically seal.

However, a change in air pressure may result in a chill inside the gun. That is, rapidly expanding gases left behind within the gun, may chill seals, or condense vapors, resulting in failure of operations of a gun. Stable thermodynamics may be achieved by minimizing the number of pressure drops to which the various chambers of a gun may be exposed. Accordingly, in one embodiment, the magazine may be handled as a unit, but the projectile magazine may be separated at will. Accordingly, the propellant portion and the ammunition portions may be loaded together, but one portion of the load (e.g. projectiles, propellant) may be loaded while leaving the other unmolested.

In certain embodiments, an apparatus (gun) may have a frame, an action (the lock), a magazine, a trigger assembly, a barrel, and the like. The gun may be made in several pieces, which may be sealed together as necessary, and removably sealed as prudent. An air chamber may provide a cavity for holding a charge of propellant (e.g. carbon dioxide, air, etc.). Ammunition may feed into a chamber to be launched down a barrel of the gun.

Suitable seals and actuators may seal a bolt in various positions, with the propellant advancing the bolt, upon actuation by a trigger, and the bolt releasing suitable quantities of propellant in order to launch the projectiles. The bolt may be driven by propellant forward, and backward. However, in certain embodiments, the bolt may be driven forward by propellant, but returned by a spring storing part of the energy of actuation of the bolt.

A magazine may include a receiver for holding a canister of propellant as a source of energy for launching projectiles. The propellant canister may be resealable by a valving system, thus tolerating removal without losing the charge of propellant in the canister. A series of valves, poppets, seals, springs, and the like, as well as a network of passages, may guide propellant gases from a magazine to the action of the gun. In certain embodiments, a head seal and tail seal may seal the valving portion or rod associated with a bolt.

Meanwhile, a trigger may actuate the bolt, launching both the bolt and its valving mechanism for a brief excursion into the chamber of the gun. As the bolt moves forward, the valving mechanism can shut off any further flow, thus discharging a limited amount of propellant with each shot. The trigger mechanism may include a simple release, but may include a comparatively sophisticated sear and latching mechanism for retaining the bolt in a ready-to-fire position. The sear may be selectively released by a trigger actuated by a user. Various spring mechanisms may return the sear to a ready-to-fire position, capturing the bolt upon return of the bolt from a fired position.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects and features of the present invention will become more fully apparent from the following description and appended claims, taken in conjunction with the accompanying drawings. Understanding that these drawings depict only typical embodiments of the invention and are, therefore, not to be considered limiting of its scope, the invention will be described with additional specificity and detail through use of the accompanying drawings in which:

FIG. **1** is a perspective view of one embodiment of an apparatus in accordance with the invention;

FIG. **2** is a partially cutaway and partially hidden-view rendering of a perspective view of one embodiment of the apparatus in FIG. **1**;

FIG. **3** is a top, cutaway, perspective view of a selected portion of the action of the apparatus of FIG. **2**;

FIG. **4** is a side, elevation, cross-sectional view of the apparatus of FIG. **2**;

FIG. **5** is a side, elevation, cross-sectional view of the apparatus of FIG. **4** in a fired position;

FIGS. **6**A–**6**B are top, plan, cross-sectional views of an alternative embodiment of an apparatus in accordance with the invention;

FIG. **7** is a perspective, partially cutaway view of one embodiment of a magazine in accordance with the invention;

FIG. **8** is a top, plan, cross-sectional view of the apparatus of FIG. **7**;

FIG. **9** is a side, elevation, cross-sectional view of the apparatus of FIG. **7**;

FIGS. **10**A–**10**C are partial, side, elevation, cross-sectional views of the apparatus of FIGS. **7**–**9** illustrating, respectively, a misalignment-detention position, an initial released position, and a subsequent released position;

FIG. **11**A is a side, elevation, cross-sectional view of an alternative embodiment of a magazine in accordance with the invention;

FIG. **11**B is a top, plan, cross-sectional view of the apparatus of FIG. **11***a;*

FIG. **12**A is a side, elevation, cross-sectional view of an alternative embodiment of an action and trigger mechanism in an apparatus in accordance with the invention;

FIG. **12**B is a top, plan, cross-sectional view of the apparatus of FIG. **12**A;

FIG. **13**A is a side, elevation, cross-sectional view of an alternative embodiment of an action and trigger mechanism in an apparatus in accordance with the invention, in a fired position;

FIG. **13**B is a top, plan, cross-section view of the apparatus of FIG. **13**A, in a fired position;

FIGS. **14**A–**14**E are side, elevation, cutaway, cross-sectional views of an alternative embodiment of an action and corresponding trigger mechanism in accordance with the invention, positioned in a ready-to-fired position, bolt-returned position, sear-returned position, and pawl-returned position, respectively;

FIG. **15** is a side, elevation, cross-sectional view of an alternative embodiment of an action and magazine, trigger, barrel, and regulator for an apparatus and method in accordance with the invention;

FIG. **16** is a side, elevation, cross-sectional view of the magazine of FIG. **15**; and

FIGS. **17A–17B** are side, elevation, cross-sectional, partially-cutaway views of the action of FIG. **15** in a ready-to-fire position and a fired position, respectively.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

It will be readily understood that the components of the present invention, as generally described and illustrated in the Figures herein, could be arranged and designed in a wide variety of different configurations. Thus, the following more detailed description of the embodiments of the system and method of the present invention, as represented in FIGS. **1** through **17**B, is not intended to limit the scope of the invention. The scope of the invention is as broad as claimed herein. The illustrations are merely representative of certain, presently preferred embodiments of the invention. Those presently preferred embodiments of the invention will be best understood by reference to the drawings, wherein like parts are designated by like numerals throughout.

Those of ordinary skill in the art will, of course, appreciate that various modifications to the details of the Figures may easily be made without departing from the essential characteristics of the invention. Thus, the following description of the Figures is intended only by way of example, and simply illustrates certain presently preferred embodiments consistent with the invention as claimed.

Referring to FIG. **1**, specifically, while referring to FIGS. **1–17**, generally, an apparatus **10** or gun **10** may be formed to have a frame **12**. The frame **12** may also be referred to as a housing **12** in an apparatus **10** in accordance with the invention. That is, since the gun **10** need not sustain the ballistic pressures typical of actual firearms, manufacturing liberties may be taken in the construction of various aspects of the gun **10**. One of those liberties may involve treating the frame **12** simply as a housing **12** for various components. Accordingly, apertures, ways, grooves, openings, penetrations, and the like, may be formed in the frame **12** in order to accommodate various aspects of the gun **10**.

In general, a gun **10** may include an action **14** or lock **14**. The action **14** is responsible for loading and firing projectiles.

The gun **10** may include a magazine **16** integrated within the gun **10** itself Unlike previous attempts to launch paintballs and the like, a magazine **16** may fit entirely within the envelope of the gun **10**. Attached to the frame **12**, or formed within the frame **12**, a barrel **20** may serve to receive and launch projectiles. Independent from the frame **12**, housings **22** may be formed around various aspects of the gun **10** in order to provide characteristic shapes, covers, shrouds, and the like.

Either integrated or attached to the frame **12**, a handle **24** or grip **24** may serve for supporting the gun **10** in a hand of a user. Although a side arm is illustrated, the gun **10** may be embodied in a rifle or other weapon configuration as desired.

Referring to FIGS. **2–5**, while continuing to refer generally to FIGS. **1–17**, a gun **10** may be formed to have an enclosure **26** proximate a back end thereof for either hiding, protecting, or pressurizing an internal cavity **27**. Integrated with the enclosure **26**, or as a separable piece distinct therefrom, a guide **28** may serve as a wall **28** for the cavity **27**, as well as for guiding various components of the gun **10**.

In general, a propellant chamber **30** may surround a cavity **31** for receiving a predetermined charge of propellant. The propellant may be compressed air, compressed carbon dioxide, pressurized propane, or other material. In certain embodiments, steam, alcohol, or other materials may be selected as a propellant. As a practical matter, propellants should provide sufficient, but limited, quantities of energy suitable for firing projectiles without substantial risk of injury to a targeted person.

A projectile **32** or ammunition **32** may typically be a gelatinous capsule containing a readily releasable pigment. For example, paintballs **32** contain a marker of highly pigmented liquid. The projectiles **32** may be formed in various shapes. Since the gun **10** has a magazine **16** capable of feeding individual projectiles, then riflings, shaped projectiles **32**, and the like may be practicable.

Between the magazine **16** and the chamber **34** associated with the barrel **20** of the gun **10**, an aperture **33**, sometimes referred to as a feed aperture **33**, connects a column of projectiles **32** between the magazine **16** and the chamber **34**. The chamber **34**, in contrast to the chamber **31** (propellant chamber or air chamber), corresponds to a chamber **34** of a conventional arm. Due to the fit of a projectile **32** within the barrel **20**, or bore **20**, the chamber portion **34** may simply be an extension of the barrel **20**. However, in certain embodiments, mechanisms for restraining the projectile from moving in the chamber **34** may be provided. Detents, springs, constrictions, and the like, may all be suitable mechanisms for retaining a projectile **32** within the chamber **34** prior to launch or firing.

A variety of seals **36** contain propellant gases. Seals **36** may be static, positioned between fixed pieces having no relative motion, or may be dynamic, positioned to seal movable members against passage of fluids along the movable surfaces thereof

In certain embodiments, a bolt **40** may include an actuator **38** or valve **38** and a head **41**. The actuator **38** provides valving and control dynamically during operation of the gun **10**. Specifically, the actuator **38** controls the inlet, containment, and discharge of propellant within the cavity **31**, or propellant chamber **31**, in a proper sequence for loading and firing the gun **10**.

The head **41** of the bolt **42** provides impetus to a projectile **32**, while also blocking the feed of additional projectiles **32** from the magazine **16**, until a proper event occurs. Likewise, until properly released, the bolt **40**, and particularly the outermost portion associated with the head **41**, operates to activate the trigger system **18**. Accordingly, in a true semi-automatic fashion, the bolt **40** permits feeding of a projectile **32** only with each cycle of the trigger mechanism **18** and each corresponding cycle of the action **14**.

A return spring **42** operates against a lip **43** at the back end of the bolt head **41** to return the bolt **40** "into battery." That is, during a firing sequence, the bolt **40** moves forward, launching a projectile **32**, and expelling propellant from the propellant chamber **31** into the projectile chamber **34**, accelerating the projectile **32** down the barrel **20**. Completing a firing cycle, if firing is to be semiautomatic, the bolt **40** must return to a ready-to-fire position in order to be released by the trigger assembly **18** again.

From return to a ready-to-fire position, the head **41** of the bolt **40** receives significant energy from the return spring **42**.

A resilient and energy-absorbent bumper **44** supported by the frame **12** of the gun **10** can absorb impact loads associated with the bolt **40** coming to rest in a ready-to-fire position.

Referring to FIG. **3**, the actuator **38** may be thought of as comprising multiple portions. For example, a rear shaft **46** or tail shaft **46** may operate as a spool valve **46** for controlling the inlet of propellant **58** into the propellant chamber **31**. A front shaft **48** or head shaft **48** may similarly operate as a spool valve during advance of the bolt **40** forward. Thus, proper shaping of the tail shaft **46** and head shaft **48** will provide dynamic tailoring of the opening and closing of access to the propellant **58** for passage through the chamber **31** and chamber **34**.

In addition to the head shaft **48**, which may be optional in certain embodiments, and refers generally to the portion of the actuator **38** that is near the head **41** of the bolt **40**, a nose shaft **50** may selectively move to form a seal for releasing propellant **58** from the chamber **31** into the chamber **34**. The nose shaft **50** has a shape, length, and associated surfaces required to promote capture of propellant **58** within the propellant chamber **31** or propellant cavity **31**. Accordingly, as the bolt **40** moves forward, both the head **41** and actuator **38** advance through the ammunition chamber **34**, initiating movement of a projectile **32**, under force of the pressure of the propellant **58** in the propellant chamber **31**. However, as the nose shaft **50** necks down to the head shaft **48** or front shaft **48**, the seal is broken, releasing the pressure acting on the bolt **40** as the propellant **58** is vented from the propellant chamber **31** into the ammunition chamber **34**.

The middle shaft **52** represents a portion of the actuator **38** that may be reduced further in diameter to provide clearance for passing propellant past the middle shaft **52** into the propellant chamber **31**. Thus, whereas the tail shaft **46** will seal off passage of propellant from the magazine **16** into the propellant chamber **31**, positioning the middle shaft **52** in a seal region permits filling the propellant chamber **31** due to the additional clearance provided by a necked-down diameter of the middle shaft **52** (mid-shaft region **52**).

Referring to FIGS. **4–6**, while continuing to refer generally to FIGS. **1–17**, a cap **54** may close a receiver **56** for holding propellant **58** in a cartridge **60** or container **60**. The cartridge **60** may reduce in size near a neck **62**. A cap **64** may seal the neck **62**, containing the propellant **58** as a compressed gas, saturated liquid, or the like. In certain embodiments, the end cap **54** may seal the receiver chamber **56**. In other embodiments, a seal **66** or washer **66** may fit snugly against the cap **64** in order to seal the opening in the cap **64** formed by a penetrator **68**. In general, a penetrator **68** may be a hollow, syringe-needle-like member **68** adapted for puncturing the metal cap **64** to access the contained propellant **58**. Through the hollow penetrator **68**, the propellant **58** may release for delivery into the action **14** of the gun **10**.

Another seal **69** may further seal the magazine **16** against the frame **12** of the gun **10**. In certain embodiments, an activator **70** may extend into the gun **10** for providing mechanical and fluid communication therewith. A seal **71**, in combination with a seal **69** may secure leak-free fluid communication between the gun and the cartridge **60** through the activator **70**. The activator **70** may be designed to be a part of the gun **10** or a part of the magazine **16**. In either event, the activator **70** is moved, by the insertion of the magazine **16** into the gun **10**, against a poppet **72** that is urged into a closed position by a spring **74**. When the magazine **16** is removed from gun, the spring **74** forces the poppet **72** and accompanying seal **76** into a closed position. The poppet **72** can only vent gases from the cartridge **60** when the poppet **72** and associated seal **73** are in an open position as illustrated in FIG. **3**.

Additional seals **76** may operate to secure the path of the propellant **58** from the cartridge **60** into the activator **70** and into a passage **78** in the gun **10**. In certain embodiments, the passage **78** may be formed in the frame **12** of the gun, which may, in turn, be secured by a seal **77**. The action **14** may contain an inlet **80** for receiving propellant **58** from the passage **78** past the seal **77**. Other seals **81** may be distributed among various components of the gun **10** in order to seal separable pieces.

Referring to FIGS. **4–5**, while continuing to refer generally to FIGS. **1–17**, a tail seal **82** may include one or more single "O" rings **82**. The tail seals **82** are configured to sealingly contact the tail shaft **46**. When the tail shaft **46** is aligned to contact the tail seals **82**, propellant **58** is sealed against intrusion into the propellant cavity **31**. If the middle shaft **52** is aligned with the tail seals **82**, the resulting clearance therebetween provides passage of propellant **58** from the inlet **80** to the propellant chamber **31**.

In certain embodiments, the cavity **27** of the enclosure **26** may be in fluid communication with the inlet **80** and the propellant chamber **31**. Thus, when the inlet **80** provides propellant **58** from the cartridge **60**, that propellant **58** may pass into the cavity **27**. If the tail shaft **46** and tail seals **82** are positioned in sealing relation, then no propellant **58** passes into the propellant chamber **31**. On the other hand, when the middle shaft **52** is aligned with the tail seal **82**, both the cavity **27** and the propellant chamber **31** are in fluid communication with the inlet **80**, receiving propellant. Thus, the cavity **27** tends to form a buffer and a reservoir **27** holding a pressurized amount of propellant **58**, and providing the pressure thereof against the tail shaft **46**, urging the bolt **40** forward.

Nose seals **84** associated with the nose shaft **50** provide a similar sealing arrangement. In certain embodiments, the nose shaft **50** is designed to be of a length such that the bolt **40** may advance down the barrel **20** a selected distance before the head shaft **48**, passes the nose seal **84**. With the bolt **40** in a retracted or ready-to-fire position, the nose seal **84** and nose shaft **50** together form a seal on the propellant chamber **31**. Upon release of the bolt, pressure within the cavity **27** urges the actuator **38** forward by acting on the tail shaft **46**. Similarly, pressure from the propellant **58** in the propellant chamber **31** acts on the cross-sectional area of the nose shaft **50** to urge the bolt **40** forward. Once the bolt **40** begins moving forward, such that the tail shaft **46** has aligned with the tail seal **82**, the propellant chamber **31** is sealed away from the inlet **80** and the cavity **27**.

Accordingly, the charge of propellant **58** contained at that point within the propellant chamber **31** is the entire charge to be used to accelerate the bolt **40** and the projectile **32**.

As the bolt **40** advances across the opening **33** and into the chamber **34** toward the barrel **20**, the nose shaft **50** eventually passes the nose seal **84**. As the reduced diameter of the head shaft **48** or the middle shaft **52** aligns with the nose seal **84**, the propellant **58** within the propellant chamber **31** is released through the opening **86** or clearance **86** between the nose shaft **50** and the attached bolt head **41**.

Securement of the bolt head **41** to the nose shaft **50** maybe accomplished in a variety of ways. In one embodiment, the head shaft **50** may be threaded into a fitting in the bolt head **41**, and the bolt head **41** may be provided with large vents **86** connected by thin webs to the nose shaft **50**. Thus, the openings **86** may be substantial, providing relatively minor resistance to flow of the propellant **58** from the propellant chamber **31** to the projectile chamber **34**.

Once the propellant **58** is free to vent from the propellant chamber **31** into the projectile chamber **34** and the barrel **20**, further acceleration of the projectile **32** is due to the expansion of the propellant **58**. Likewise, further urging of the bolt **40** forward by the propellant **58** ceases.

As the bolt **40** progresses forward down the chamber **34** and barrel **20**, the return spring **42** is compressed against a lip **43** of the head **41** of the bolt **40**. Thus, the energy provided by the propellant **58** in the propellant chamber **31** is resisted by the return spring **42** at an ever increasing value as the bolt **40** moves forward. Thus, once the pressurization of the propellant **58** ceases, the return spring **42** urges the lip **43** of the head **41** to reverse direction, returning toward the rear of the gun **10** and action **14**.

Referring to FIGS. **4–5**, while continuing to refer generally to FIGS. **1–17**, the chamber **30** may provide a diffuser **88** for optimizing the flow of propellant from the propellant chamber **31** (cavity), through the bolt **40**, and into the chamber **34** and barrel **20**. The diffuser may be important since extremely high mach numbers arise from the differential pressures between the propellant chamber **31** and the barrel **20** upon initial opening of the nose seal **84**.

A trigger assembly **18** may include a trigger **90** having a return spring **91** for positioning the trigger **90** in a ready-to-fire position. Upon actuation of the trigger **90** by a user, the trigger assembly **18** releases the lip **43** of the head **41** of the bolt **40**, and propellant pressure acting on the tail shaft **46** and nose shaft **50** propels the bolt **40** forward. Movement of the bolt **40** down the barrel **20**, begins acceleration of the projectile **32**, through the aperture **33** and blocks any further entry of projectiles **32** from the magazine **16** into the chamber **34**.

Shortly after movement begins by the bolt (including the actuator **38** and head **41** of the bolt **40**), at a position and associated time defined by the position of the middle shaft **52**, the tail shaft **46** seals off the propellant chamber **31** from the inlet **80** and the buffering cavity **27**. The bolt **40** then continues forward down the barrel **20** until the nose shaft **50** passes the nose seal **84**. A clearance between the nose seal **84** and the front shaft **48** or middle shaft **52** provides sufficient freedom for the propellant **58** to exit the propellant chamber **31** and cease urging the bolt **40** forward. The propellant **58** continues down the barrel **20** behind the projectile **32**, expanding as it goes.

Having vented the propellant **58** to the barrel **20**, and ultimately to atmospheric pressure, the bolt **40** is urged rearwardly by the return spring **42**. The return spring **42** acts on the lip **43** returning the bolt **42** against a bumper **44**. At this position, the nose seal **84** has closed the propellant cavity **31**, and the middle shaft **52**, upon alignment with the tail seal **82**, communicates propellant **58** from the cavity **27** and inlet **80** into the propellant chamber **31** for refilling.

Referring to FIGS. **6A–6B**, while continuing to refer generally to FIGS. **1–17**, an actuator **38** may be designed to operate as the sole element of a bolt **40**. In the embodiment of FIG. **6** (e.g. **6A–6B**), double nose seals **84***a*, **84***b* and double tail seals **82***a*, **82***b* seal the propellant chamber **31**. In a ready-to-fire position illustrated in FIG. **6A**, the actuator **38** has positioned a clearance **83** or necked-down region **83** over the front tail seal **82***b*. Thus, the inlet **80** has fluid communication for passing propellant into the propellant chamber **31**. Meanwhile, a shoulder **85** of the nose shaft **50** seals against the rear nose seal **84***a*. Similarly, a nose **89** seals against a front nose seal **84***b*. Upon release of the actuator **38**, the actuator **38** moves rearwardly toward the tail seals **82***a*, **82***b*. The clearance **83** moves past the front tail seal **82***b*, putting the maximum diameter of the tail shaft **46** against the front tail seal **82***b*. This effectively seals the inlet **80** away from the propellant chamber **31**. Meanwhile, the specific distances involved are calculated to provide coordinated sealing of the inlet **80** before breaking the sealing effect of the nose seal **84***b*.

Referring to FIG. **6B**, as the actuator **38** moves rearwardly, the front face **87***a* is first exposed to the pressure of the propellant chamber **31** in opposition to the force previously applied only to the rear face **87***b* of the shoulder **85**. Thus, once the shorter shoulder **85** passes the rear nose seal **84***a*, propellant moves in front of the front face **87***a*, more rapidly urging the retreat (retraction, rearward direction) of the actuator **38**.

Eventually, the nose **89** of the nose shaft **50** of the actuator **38** clears the front nose seal **84***b*, releasing the propellant **58** in the propellant chamber **31** into the projectile chamber **34**. The pressure of the propellant **58** released into the chamber **34** accelerates a projectile **32** down the barrel. A return mechanism moves the actuator forward to the position illustrated in FIG. **6A**.

The nose **89** first seals with the nose seal **84***b*, then the shoulder **85** seals with the rear nose seal **84***a*. Thereafter, the tail shaft **46** exposes the front tail seal **82***b* to the clearance **83**, again filling the propellant chamber **31** through the inlet **80**. The tail seal **82***a* maintains a sealing relationship with the tail shaft **46** at all times in certain embodiments.

Referring to FIGS. **7–10C**, while continuing to refer generally to FIGS. **1–17**, alternative designs for a magazine **16** provide various advantages. For example, in certain embodiments, the projectiles **32** may be stored in a stacked arrangement. A pad **98** may conform to the shape of the projectiles **32** in order to aid advancing the column of projectiles **32** upward along the magazine. In certain embodiments, the pad **98** is advanced by a spring **96** or feed spring **96** urging the pad **98** upward toward the projectile chamber **34**.

However, a retainer **100** equipped with a detent **102** or tooth **102** provides a restriction on motion of the pad **98** above the spring **96**. In certain embodiments, the magazine **16** may include a rail **104** having teeth **105** or projections **105**. Similarly, a corresponding rail **106** may have teeth **107** of a corresponding pitch and size. Between the teeth **105** and between the teeth **107**, gaps **108** remain. The teeth **105, 107** are sized to at least fill the gaps **108**. That is, when the rail **104** is offset with respect to the rail **106**, then the teeth **105** may be misaligned with the teeth **107**, or, more appropriately, asynchronously aligned with the teeth **107**. Thus, the teeth **105** are aligned with gaps **108** in the rail **106**. Similarly, the teeth **107** are aligned with the gaps **108** between the teeth **105**.

When the teeth **105, 107** are aligned, or nearly so, the gaps **108** are sufficient that the retainer **100** urges the detent **102** into the gaps **108**. This condition may exist when the magazine **16** is removed from the gun **10**. Thus, the spring **96** is restrained by the retainer **100** and pad **98**, from advancing. Thus, the projectiles **32** remain in the magazine and are not urged to exit.

By contrast, when the teeth **105, 107** are asynchronously aligned, the detent **102** encounters a substantially continuous wall represented alternately but continuously by the teeth **105, 107**. Thus, the detent **102** cannot penetrate any gaps **108**, the gaps **108** being blocked from access by intervening teeth **107, 105**, respectively.

The rail **104** may extend a distance sufficient to engage a portion of the gun **10**, such as a portion of the gun frame **12**, in order to provide the misalignment of the teeth **105** from the teeth **107**. In certain embodiments, the rail **104** may be thought of as a slide **104**, urged into alignment with the rail **106**. Inserting the magazine **16** into the gun **12** actuates the rail **104** misaligning (asynchronously aligning) the teeth **105** with respect to the teeth **107**.

Referring to FIGS. **11A–11B**, an alternative embodiment for a magazine **16** may be formed halves **110***a*, **110***b*. The halves **110***a*, **110***b* may fit together for insertion into a portion of the frame **12** of the gun **10**. In certain embodiments, the magazine **16** may be formed of halves **110***a*, **110***b* having respective, cooperating, mutually engaging slides **112***a*, **112***b*.

In certain embodiments, a magazine **16** may hold approximately 10 rounds of projectiles **32**. By contrast, a common size of cartridge **60** may contain sufficient propellant **58** to fire twenty-five to thirty projectiles **32**. Thus, it is advantageous to a user if a portion **110***b* of a magazine **16** containing projectiles **32** can be extracted and reloaded independently from the portion **110***a* containing the propellant cartridge **60**.

A blowdown process is a thermodynamic event in which a pressurized quantity of fluid is allowed to expand rapidly. During a blowdown process, massive temperature drops may occur. Even in comparatively small quantities of propellant **58**, blowdown of the propellant within the cavity **27** may be sufficient to chill elements of the action **14**.

Chilling, in and of itself, can affect the clearances and tolerances of components of the action **14**. Moreover, the presence of any water vapor within the action **14**, combined with a rapid decrease in temperature due to a blowdown process, can result in small quantities of frozen water at inconvenient locations in the action **14**. Thus, minimizing the number of blowdowns experienced by the action **14** is one way to improve the reliability of operation of the action **14**.

Since expansion of propellant **58** from the propellant chamber **31** is also a blowdown process, continued chilling of the action **14** is already occurring in the normal course of operation of the gun **10**. Accordingly, it is beneficial to minimize any additional cooling that may occur. Thus, the ability to leave the cartridge **60** and its portion **1110***a* of the magazine **16** in place may be very beneficial.

In the embodiment of FIGS. **11A–11B**, a key **114** may operate by any suitable mechanism to release the projectile portion **110***b* of the magazine **16** from engagement with the propellant portion **110***a*. The key **114** may be a knob, button, slide, clip, or other mechanism suitable for selectively engaging and disengaging the projectile portion **110***b* from the propellant portion **110***a*. The key **114** may be exposed to the outside surface of the gun such that a user may have ready access thereto for releasing the projectile magazine **110***b*.

Referring to FIGS. **12A–13B**, specifically, while continuing to refer generally to FIGS. **117**, a trigger **90** may pivot about a pin **116** in response to a user urging the trigger **90** against a linkage **118** in a rearward direction **119**. The linkage **118** may be a slide **118** in certain embodiments.

One principal function of a linkage **118** is to transfer a rearward **119** motion of the trigger **90** to release a sear **120** or latch **120** securing a bolt **40** in a ready-to-fire position. A pin **121** penetrating the trigger **90** may pivotably secure a linkage **118** to the trigger **90**. Actuation of the trigger **90** moves the linkage **118** in a rearward direction **119**, urging rotation of the sear **120** about a pin **122** therethrough. The pin **122** serves as a pivot **122** for one embodiment of a sear **120** as illustrated in FIGS. **12A–13B**.

A return spring **124** may urge the trigger **90** into a ready-to-fire position. Similarly, a return spring **126** may urge the sear **120** into a ready-to-fire position. In one embodiment, a lip **128** on the sear **120** engages a lip **130** of the bolt **40**, and particularly of the bolt head **41**. The sear **120** includes a ramp **132** or ramped portion **132** for engaging a surface **19** of the linkage **118**. The surface **19** acts to urge the sear **120** into rotation about the pin **122**, in response to rearward **119** motion of the trigger **90** and linkage **118**. As the sear **120** is rotating clockwise, the lip **128** releases the lip **130** (e.g. **43**), freeing the bolt **40** to advance forward into the chamber **34**, covering the feed aperture **33**, and launching a projectile **32** down the barrel **20**.

Upon completion of the firing sequence, the return spring **42** is compressed as illustrated in FIG. **13A**. Meanwhile, the catch **130** or lip **130**, in moving forward during the operation of firing, strikes a wall **139** associated with a wedge **138** in the linkage **118**, driving the wedge **138** laterally away from the sear **120**. The wedge **138** remains thus misaligned, against the urging of a spring **137**, until the return of the bolt **40** to the ready-to-fire position.

Following expulsion of propellant **58** from the propellant chamber **31**, past the nose seal **84**, through the head **41** of the bolt **40**, and into the bore **20** of the gun **10**, the compressed return spring **42** urges the head **41** and bolt **40**, including the actuator **38** in a rearward direction.

Continuing to refer specifically to FIGS. **12A–13B**, while continuing to refer generally to FIGS. **1–17**, the trigger **90** and linkage **118** return forward under the urging of the return spring **124**. Nevertheless, the lip **130** of the head **41** of the bolt **40** strikes a slope **132** or ramp **132** of the sear **120** dropping the lip **128** or rotating the lip **128** clockwise away from the lip **130**. After the lip **130** has passed the lip **128** of the sear **120**, the spring **126** will urge the sear **120** back into a ready-to-fire position. As an added assurance, the energy of the bolt **40** is applied to strike the lip **130** against a pawl **134** on the back end of the sear **120** rotating the sear counterclockwise and into engagement of the lip **128** with the lip **130**. At this point, the linkage **118** has returned forward, clearing the way for the wedge **138** and associated wall **139** to move toward the center of the action **14**, at the urging of the spring **137**. Thus, the wedge **138** may return into alignment for activating the sear **120** upon the next actuation of the trigger **90**.

Referring to FIGS. **14A–14A**, while continuing to refer generally to FIGS. **1–17**, an alternative embodiment of a trigger mechanism **18** may also rely on a trigger **90** connected to a linkage **118** for activating a sear **120** restraining a bolt **40**. Initially, as illustrated in FIG. **14A**, all components are positioned in a ready-to-fire position. From this position, the trigger **90** may be urged in a rearward direction **119**, moving a slide **118** or linkage **118** backward, likewise. The trigger **90** moves against the resistance of return spring **124** urging the trigger forward or counterclockwise.

A sear rotator **142** pivots about a pin **143**. A pawl **144** or tip **144** on the sear rotator **142** engages a portion of the sear **120**. Upon a rearward **119** motion of the linkage **118**, the sear rotator **142** is rotated counterclockwise, drawing the sear **120** down in a clockwise motion about the pin **122**. Upon sufficient motion, dictated by the interference between the sear **120** and the pawl **144**, the sear barb **145** or pawl **145** disengages from the lip **130** of the bolt **40**.

As discussed above, since the propellant chamber **31** is pressurized, the tail shaft **46** and nose shaft **50** urge the bolt

40 forward. The bolt 40 moves forward accordingly, as illustrated in FIG. 14B. The projectile 32 and bolt 40 are launched forward, with the propellant 58 escaping between the middle shaft 52 and nose seal 84 until the environment and the propellant chamber 31 are substantially in pressure equilibrium. Thereupon, the return spring 42 urges the lip 130 and bolt 40 in a rearward direction 119.

As the bolt 49 moves rearward 119, the lip 130 makes contact with a sear release 146. The sear release 146 slides rearward 119 under the load applied by the firing bolt. The sear release 146 is free to move a limited distance along a slot 148. As the sear release 146 moves along the slot 148, contact is made with a rotating pin 143 fixed in the sear rotator 142. The sear rotator pin 143 is solidly attached to the sear rotator 142, operating such that the sear release 146 pushes the pin 143 in a rearward direction 119, moving the sear rotator backwards 119 therewith.

As the firing bolt 40 continues to move the sear release 146 backwards 119, with the sear rotator 142, the sear release 146 will contact a portion of the frame 12, or a wall 150 of the chamber 30 enclosing the propellant cavity 31. By the time or position of contact, the sear rotator 142 has moved sufficiently rearward 119 to be completely free from any contact with the sear 120. The sear 120 is now free to rotate clockwise with the urging of the return spring 126. The sear 120 will thus move into the ready-to-fire position, recapturing the lip 130 of the bolt 40 as illustrated in FIG. 14E.

As illustrated in FIGS. 14B–14D, the sear rotator 142 has a curved portion 154. As the sear rotator 142 moves forward, a curved portion 154 associated with the sear rotator 142 contacts the sear, rolling the sear rotator 142 counterclockwise into the final engagement position.

Referring to FIGS. 15–17A, while continuing to refer generally to FIGS. 1–17, certain alternative embodiments may provide additional features in an apparatus and method in accordance with the invention. For example, a magazine catch 156 may provide for ready release of a magazine 16 from the frame 12 of a gun 10. The magazine catch 156 may operate to release a magazine 16 in one embodiment. Alternatively, or additionally, the magazine catch 156 may serve to release only the ball chute portion 158 of the magazine 16 from the remainder of the magazine 16 containing the propellant 58. In one embodiment, a button 160 may operate with actuate the magazine catch 156. In certain embodiments, the magazine catch 156 may merely be a depression or detent that can interfere with or otherwise engage the button 160, selectively securing and releasing the ball chute 158 from the remainder of the magazine 16.

In certain embodiments, a spring 162 may urge the button 160 toward a secure position. Thus, actuation by a user may be a manual override by pushing the button 160 out of engagement with a magazine catch 156, releasing the ball chute 158, entire magazine 16, or the like.

In the embodiment of FIGS. 15–17B, an alternative embodiment for containing the projectiles 32 in the ball chute 158 may rely on a clip 164 or retainer 164. In one embodiment, the clip 164 has a portion thereof presenting a pocket 165 or depression 165 as the clip 164 rotates about a pin 166. Upon insertion into the gun 10, the clip 164 may be rotated about the pin 166 by a catch 167. The catch 167, associated with the gun 10, may operate by interference with complete insertion of the clip 164 or retainer 164. Accordingly, the catch 167 rotates the clip 164 clockwise against a return spring 168, releasing the projectiles 32 for insertion through the aperture 33 and into the chamber 34 of the gun 10.

A projectile 32 itself, once inserted into the projectile chamber 34, will restrain the column of projectiles 32 in the chute 158 against further delivery. During firing, the bolt head 41 obstructs the column of projectiles 32. Upon removal of the clip 16 or of the chute 158 of projectiles, the catch 167 releases the retainer 164 or clip 164, which then rotates the pocket 165 counterclockwise against the first projectile 32 in the chute 158. Thus, the projectiles 32 cannot be delivered from the chute 158 in the absence of the interfering catch 167 of the gun 10.

Referring to FIG. 16, while continuing to refer to FIGS. 1–17 generally, the magazine 16 may include various embodiments. In some embodiments, the activator 70 may be part of the magazine 16. In other embodiments, the activator 70 may be a part of the gun, engaging the poppet 72 of the magazine.

In any event, the alternative embodiment of FIG. 16 may rely on an independent housing 170 for the cartridge 60. However, in other embodiments, simple retention of the cartridge 60 with proper sealing by a seal 66 near the head 64 thereof may be sufficient. Likewise, manufacturing considerations may require a plug 172 for simplified assembly of the components associated with delivery and control of propellant 58 from the cartridge 60.

Referring to FIGS. 17A–17B, while continuing to refer generally to FIGS. 1–17, a regulated embodiment of a gun 10 in accordance with the invention may include several optional components. For example, a bushing 176 may provide a perforated path for supporting and guiding the tail shaft 46 of the actuator 38, while continuing to provide delivery of propellant 58 from the inlet 80 into the propellant chamber 31. An annular inlet 178 may circumnavigate the guide 28, sealed against escape of propellant 58.

In the embodiment of FIGS. 17A–17B, a regulator 180 may provide a regulated pressure to the propellant chamber 31. Thus, the propellant chamber 31 will not have such a wide variation in contained mass as temperature changes, or as the content of the cartridge 60 is dissipated.

In one embodiment, a spring 182 contacts a regulator plate 184, urging the plate 184 toward a base 192. A seal 186 maintains a propellant-proof contact for sealing the spring 182 away from the propellant 58. Thus, the outlet 188 is the only escape for propellant 58 introduced from the cartridge 60.

A poppet 190 may be activated by a spring 191, in opposition to the spring 182. The spring 191 urges the poppet 190 toward the base 192, where a seal 194 closes fluid communication between the poppet 190 and the outlet 188. A passage 196 through the base 192 communicates propellant from the poppet into the outlet 188.

Meanwhile, a passage 197 communicates propellant from the cartridge 60, and from the activator 70 to the poppet. A pin 198 of the poppet 190 contacts the plate 184. Accordingly, if the pressure of the poppet is sufficient that the plate 184 experiences sufficient force to move the spring 182 toward a pre-determined position, then the spring 182 compresses, the plate 184 moves (left in the illustration), as does the poppet 190, and its associated pin 198 moves through the passage 196 in the base 192, placing the seal 194 in contact with the base 192. Accordingly, the flow of propellant 158 ceases. Thus, the available pressure at the outlet 188 feeding the inlet 80 into the bushing 176 and the propellant chamber 31 assures more equal distribution of propellant 58 between various shots.

The bolt 40, comprising an actuator 38 and head 41 operates substantially as described hereinbefore. However, the geometries may alter in accordance with a designer's choice. Thus, greater or lesser numbers of components may be manufactured in order to accomplish all of the functionality. For example, the cavity **27** in the cap **26** of FIG. **17**A seals against the guide **28**. However, the guide **28** fits within the housing **22** of the gun **10**. In other embodiments, the cap **26** and guide **28** may be aligned in sequence forming a portion of a housing **22** (see, e.g. FIG. **3**).

From the above discussion, it will be appreciated that the present invention provides a paintball gun sized and designed to appear like and operate in a manner similar to a conventional gun. A dual-action firing bolt moves forward, assisting in launching a projectile, under cast pressure. The bolt then releases the compressed gas to carry the projectile down the barrel. Return springs operate to move the bolt and its valves to a ready-to-fire position. Similarly, trigger actuation mechanisms are spring-actuated to return to the ready-to-fire position. A removable magazine stores projectiles and propellant. The magazine is small enough to fit into a handle of a pistol. A user may selectively release just the projectile portion of the magazine, in order to leave the propellant undisturbed until fully expended. The magazine can be completely removed without substantial loss of propellant.

The present invention may be embodied in other specific forms without departing from its structures, methods, or other essential characteristics as broadly described herein and claimed hereinafter. The described embodiments are to be considered in all respects only as illustrative, and not restrictive. The scope of the invention is, therefore, indicated by the appended claims, rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

What is claimed and desired to be secured by United States Letters Patent is:

1. A gun comprising:

a frame for supporting the gun;

a magazine comprising a connector selectively securing the magazine to the frame, a propellant reservoir comprising a seal maintaining the reservoir sealed against the loss of propellant when the magazine is removed from the frame, and a projectile store comprising a retainer preventing the release of projectile when the magazine is removed from the frame;

a barrel secured to the frame to accelerate a projectile;

a propellant metering chamber having a substantially fixed volume; and

an action secured to the frame and including a bolt, the bolt comprising a first integrated valving surface positioned to selectively seal the propellant metering chamber from the propellant reservoir; and a second integrated valving surface positioned to seal the propellant metering chamber from the barrel.

2. The gun of claim **1**, wherein the bolt comprises a frontal driving surface integrally attached to the bolt to feed projectile into the barrel and wherein the bolt and frontal driving surface move in rigid body motion together.

3. The gun of claim **1**, wherein the first and second valving surfaces are rigidly attached to the bolt and wherein the bolt and first and second valving surfaces move in rigid body motion together.

4. The gun of claim **1**, wherein the magazine is a single integrated monolith.

5. The gun of claim **1**, wherein the projectile store comprises a connector selectively releasing the projectile store from the magazine, while leaving the propellant reservoir operably connected to the gun, the retainer preventing the release of projectile when the projectile store is removed from the magazine.

6. The gun of claim **1**, further comprising a trigger operably connected to the frame and wherein the bolt further comprises a frontal driving surface, the frontal driving surface feeding a single projectile into the barrel for each complete cycle of motion of the trigger.

7. The gun of claim **1**, wherein the first integrated valving surface is positioned relative to the second valving surface such that the first valving surface seals the metering chamber from the propellant reservoir whenever the second valving surface is not sealing the metering chamber from the barrel.

8. The gun of claim **1**, wherein the frame is shaped as a sidearm having a handle containing and enclosing the magazine, the magazine shaped to hold projectile comprising a comparatively soft, deformable outer shell containing a flowable material.

9. The gun of claim **1**, wherein the first and second valving surfaces are rigidly attached to the bolt, the bolt further comprising a frontal driving surface positioned to feed projectiles from the magazine into the barrel, the first and second valving surfaces, the frontal driving surface and the bolt being rigidly coupled and moving in rigid body motion together.

10. The gun of claim **9**, wherein the magazine is a single integrated monolith.

11. The gun of claim **10**, wherein the propellant reservoir comprises a seal maintaining the reservoir sealed against the loss of propellant when the magazine is removed from the frame, and wherein the projectile store comprises a retainer preventing the release of projectile when the magazine is removed from the frame.

12. The gun of claim **11**, wherein the projectile store comprises a connector selectively releasing the projectile store from the magazine, while leaving the propellant reservoir operably connected to the gun, the retainer preventing the release of projectile when the projectile store is removed from the magazine.

13. The gun of claim **12**, further comprising a trigger operably connected to the frame, the frontal driving surface feeding a single projectile into the barrel for each complete cycle of motion of the trigger.

14. The gun of claim **13**, wherein the first integrated valving surface is positioned relative to the second valving surface such that the first valving surface seals the metering chamber from the propellant reservoir whenever the second valving surface is not sealing the metering chamber from the barrel.

15. The gun of claim **14**, wherein the frame is shaped as a sidearm having a handle containing and enclosing the magazine, the magazine shaped to hold projectile comprising a comparatively soft, deformable outer shell containing a flowable material.

16. A gun comprising:

a frame for supporting the gun;

a magazine comprising a connector selectively securing the magazine to the frame, a propellant reservoir comprising a seal maintaining the reservoir sealed against the loss of propellant when the magazine is removed from the frame, and a projectile store comprising a retainer preventing the release of projectile when the magazine is removed from the frame;

a barrel secured to the frame to accelerate a projectile;

a propellant metering chamber; and

an action secured to the frame and including a bolt, the bolt comprising a first integrated valving surface positioned to selectively seal the propellant metering chamber from the propellant reservoir; and a second integrated valving surface positioned to seal the propellant metering chamber from the barrel.

17. A gun comprising:

a frame for supporting the gun;

a magazine comprising a connector selectively securing the magazine to the frame, a propellant reservoir comprising a seal maintaining the reservoir sealed against the loss of propellant when the magazine is removed from the frame, and a projectile store comprising a retainer preventing the release of projectile when the magazine is removed from the frame;

a barrel secured to the frame to accelerate a projectile; and

an action secured to the frame and including a bolt, the bolt comprising a valving surface positioned to selectively control discharge of propellant.

* * * * *